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A CONSPECTUS OF MEXICAN, WEST INDIAN, CENTRAL AND SOUTH AMERICAN SPECIES AND VARIETIES OF SALIX

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In March 1917, at the request of Professor SARGENT, director of the Arnold Arboretum, I commenced a study of the American willows. A monograph of the genus *Salix* as far as it is represented in America[1] is certainly badly needed, but the attempt to investigate thoroughly the numerous species and forms described since ANDERSSON wrote his review in 1868 will prove a difficult task. It is not without a great deal of hesitation, therefore, that I have undertaken it, and I venture to ask the assistance of every one interested in the study of willows. I have already made a rather extensive investigation of the forms belonging to the PLEIANDRAE group (sect. NIGRAE, TRIANDRAE, PENTANDRAE subsect. LUCIDAE, and BONPLANDIANAE) and to sect. LONGIFOLIAE. At present I am occupied with the species of the sect. ARTICAE,

[1] In regard to the willows of the Old World it may be mentioned that there is a good account of those of Central Europe by O. v. SEEMEN in ASCHERSON and GRAEBENER, Syn. Mitteleurop. Fl. **4**:54–350. 1908–9. Of the species of Eastern Asia and of the Himalayas I have given an enumeration in SARGENT, Pl. Wilson. **3**:40–179. 1916. The willows of Central and Western Asia and those of Northern Europe and Northern Asia are very imperfectly known. I believe, however, that Rev. S. J. ENANDER, Lillherrdal, Sweden, the foremost living salicologist, is preparing a monograph of the whole genus.

RETUSAE, and RETICULATAE. I shall not deal with the forms of sect. CORDATAE because C. R. BALL, the well known salicologist at Washington, D.C., has already undertaken a monograph of this special group. Should anyone else be interested in a special study of any other section or group of the North American willows I should be very glad to hear from him.

In this article I intend to discuss the willows known from Mexico, Central America, and South America. There are among them many forms which, in my opinion, need a careful study in the field, and which are more or less closely related to forms from the southern parts of the United States. So far as I know, there has never been an attempt to give a critical review of these willows, but it seems to me impossible to determine any Mexican willow without having tried to interpret properly the species already described from that region.

I wish to express my thanks to the gentlemen in charge of the following herbaria for the opportunity to study the material contained in the different collections: Herbarium of the Arnold Arboretum, Gray Herbarium, Herbarium of the Missouri Botanical Garden, Herbarium of the New York Botanical Garden, and the United States National Herbarium at Washington.

The last enumeration of the Mexican willows was given by W. B. HEMSLEY (Botany, Biol. Central. Amer. 3:179–180. 1883), but there is no critical examination of them. Since then several new species have been described by O. v. SEEMEN and by W. W. ROWLEE, which partly, as will be shown in the following notes, are founded on a wrong interpretation of already existing species. Unfortunately, the types of most of those species are in European herbaria, and I have not been able to examine them, especially the types of the species established by MARTENS and GALEOTTI mostly on sterile branches. In consequence of this lack of important material I am not sure that my interpretation is correct in every case. Not only a careful study of the type specimens but also a more careful investigation of most of the species in the field is needed, and it is indeed the main purpose of this paper to draw the attention of all interested in the flora of Mexico and South America to what is still unknown of the willows of those countries.

Clavis specierum

Stamina 3 vel plura

Folia adulta ramulorum sterilium surculorumque utrinque concoloria, viridia, linearia, lineari-lanceolata vel anguste lanceolata (rarius in surculis late lanceolata), utraque pagina stomatibus pl. m. aequinumerosis instructa

Ramuli annotini biennesque pl. m. rubescentes vel purpurascentes; ovaria pedicellique glabri

Fructus perfecte maturi ovoidei, ovoideo-oblongi vel elliptici, apice vix vel tantum breviter attenuati, pedicello brevi iis pleroque 4–5plo breviore glandulam circ. 2–3plo superante suffulti; folia linearia vel lineari-lanceolata (rarius in surculis *S. Humboldtianae* var. *Martianae* late lanceolata), stipulae intus (an semper?) eglandulosae . . . . . 1. *S. Humboldtiana*

Fructus perfecte maturi ovoideo-lanceolati, apice satis attenuati, pedicello satis variabili glandulam 2–5plo superante suffulti; folia lineari-lanceolata ad late lanceolata; stipulae intus pl. m. glanduliferae . . . . . 2. *S. nigra*, var. *Lindheimerii*

Ramuli annotini biennesque pl. m. distincte flavescentes vel flavo-cinerei; ovaria fructusque vel pedicelli tantum saepe pilosi; fructus ovoideo- vel anguste elliptico-lanceolati, apice pl. m. attenuati, plerique satis longe pedicellati . . . . . 3. *S. Gooddingii*

Folia adulta ramulorum sterilium surculorumque subtus discoloria, glaucescentia

Ramuli annotini biennesque flavescentes vel flavi; folia superne stomatibus numerosis instructa; petioli satis tenues et longi, quam lamina vix ultra 6plo breviores . . . . . 4. *S. amygdaloides* var. *Wrightii*

Ramuli annotini biennesque rubescentes vel purpurascentes vel tomentelli; folia superne nunquam stomatifera

Fructus satis parvi et crassi, breviter ovoideo-conici, apice vix vel paullo attenuati, 4–5 mm. longi, pedicello satis crasso iis 4–5plo breviore excluso, vel pedicelli (basisque fructuum) pilosi

Ramuli annotini dense tomentosi; folia initio subtus dense villoso-tomentosula; petioli breves, vix ad 8 mm. longi; amenta mascula parva, tenuia, vix ad 3:0.8 cm. magna; fructus conferti circ. 4 mm. longi, basi pedicelloque pilosi . . . . . 5. *S. jaliscana*

Ramuli annotini glabri (hornotini tantum interdum pilosi); folia subtus semper glabra vel cito glabrescentia vel petioli foliorum majorum ultra 10 mm. longi; amenta saepissime serotina, in axillis foliorum adultorum apparentia, vel coetanea, mascula pleraque 4–6 cm. longa; fructus circ. 5 mm. longi, pedicello 4–6plo breviore excluso, glabri . . . . . 6. *S. Bonplandiana*

Fructus 5–9 mm. longi, apice subito vel sensim attenuati vel pedicello gracili tantum duplo breviore instructi

Stipulae in facie intus pl. m. glanduliferae, parvae vel nullae; folia matura superne vivide viridia, nitidula, margine saepissime satis indistincte et adpresse denticulata; fructus vix ultra 6 mm. longi, pedicello subduplo ad 3plo breviore excluso. . . . . 7. *S. laevigata*

Stipulae in facie intus tantum pl. m. pilosae vel glabrae, saepe (saltem in surculis) satis magnae; folia matura superne pl. m. sed obscure viridia, margine saepissime argutius glanduloso-serrato-denticulata; fructus 6–10 mm. longi, pedicello pleroque subduplo vel duplo breviore excluso. . . . . 8. *S. longipes*

Stamina tantum 2

Folia minima vel parva, pl. m. linearia vel lanceolata, utrinque aequaliter stomatifera, vel flores masculi semper glandulis 2 (ventrali dorsalique[2]) instructi, vel amenta tardiva, ramulos satis longos foliatos terminantia anguste linearia

Amenta brevia, mascula 5–13 mm. longa et circ. 8 mm. crassa, feminea satis pauciflora, fructifera haud ultra 2:1.2 cm. magna; antherae minimae, globosae vel breviter ellipticae, haud vel paullo longiores quam latae; stigmatum lobi lineares vel lineari-lanceolati. . . . . 9. *S. taxifolia*

Amenta longiora vel antherae ellipticae, circ. 1.5plo ad 2plo longiores quam latae vel stigmatum lobi breves oblongi

Flores masculini glandulis 2 instructi; ovaria glabra vel pl. m. pilosa, pilis haud micantibus. . . . . 10. *S. exigua* var.

Flores masculini glandula tantum ventrali instructi; ovaria densissime sericeo-villosa, pilis micantibus. . . 11. *S. longifolia* var. *angustissima*

Folia majora vel latiora et nunquam superne stomatifera (si folia sunt parva glandula dorsalis in floribus masculis deest et ovaria longe pedicellata sunt)

Amenta in axillis foliorum adultorum apparentia, vix ultra 2 cm. longa, vel flores masculi (in *S. Schaffnerii* ignoti) etiam glandula dorsali parva praediti; stigmata parva; ovaria pedicellique glabri vel sparse pilosi

Ramuli hornotini annotinique tomentosi; folia subtus (saltem in costa) pl. m. tomentella

Gemmae foliiferae apice pl. m. rostratae, ad 8 mm. longae, glabrae, vel apice sparse pilosae; pedicelli ovariorum glandula 2–2.5plo longiores, bracteam haud superantes. . . . . 12. *S. Hartwegii*

Gemmae foliiferae tantum acutae, vix ultra 6 mm. longae, pl. m. villoso-tomentellae; pedicelli ovariorum graciles, glandula 4–5plo longiores, bracteam pl. m. superantes. . . . . 14. *S. Schaffnerii*

Ramuli semper glabri; folia glabra. . . . . 13. *S. mexicana*

Amenta praecocia vel coetanea; flores masculi tantum glandula ventrali instructi

Inflorescentiae satis magnae ultra 2.5 cm. longae; folia etiam mediocra ultra 2.5 cm. longa.

[2] With regard to the nomenclature of these glands see my note in SARGENT, Pl. Wils. 3:94. 1916.

Ovaria glabra, tantum pedicelli interdum pilosi; stigmata brevia; filamenta glabra, libera vel $\frac{1}{5}$–$\frac{1}{3}$ coalita

Folia lanceolata, oblanceolata vel anguste elliptica, saepissime ultra 3plo longiora quam lata; amenta mascula satis anguste cylindrica, vix plus quam 12 mm. crassa; filamenta basi pl. m. coalita; stigmata minima, stylis pluriplo breviora; bracteae pl. m. obovatae, apice valde obtusae vel truncatae . . . . . 15. *S. lasiolepis*

Folia elliptica vel late elliptico-lanceolata, vix ultra 3plo longiora quam lata; amenta mascula crasse cylindrica, 1.5–2 cm. crassa; filamenta libera; bracteae oblongae, pl. m. acutae; stigmata mediocra stylis fere aequilonga . . . . . 16. *S. Rowleei*

Ovaria (in *S. oxylepide* ignota) villosa, stigmata lanceolata; filamenta basi pl. m. pilosa, libera

Bracteae anguste lanceolatae, apice distincte acutae vel breviter acuminatae . . . . . 17. *S. oxylepis*

Bracteae oblongae, apice pl. m. obtusae vel subtruncatae, rarius acutiusculae . . . . . 18. *S. paradoxa*

Inflorescentiae parvae, ut videtur vix ad 1 cm. longae; folia visa nondum matura tantum ad 1.8 cm. longa (vide etiam *S. Endlichii*, in nota post *S. canam*) . . . . . 19. *S. cana*

Enumeratio sectionum specierumque

Sect. I. NIGRAE Loudon, Arb. Frut. Brit. **3**:1529. 1838; SCHNEIDER, Ill. Handb. Laubh. **1**:32. 1904.—Sect. AMYGDALINAE Ball in Coult. and Nels., New Man. Rocky Mt. Bot. 129. 1909, quoad *S. nigra*.

The species belonging to this well distinguished section are *S. nigra* Muhl., *S. Humboldtiana* Willd., and *S. Gooddingii* Ball. ANDERSSON (K. Svenska Vet. Akad. Handl. **6**:15. 1867; and DC. Prodr. **16**^{2}:199. 1868) refers *S. Humboldtiana* to his section AUSTRO-AMERICANAE vel HUMBOLDTIANAE, but he also includes *S. Bonplandiana* Kth., which certainly does not belong to the same group. *S. nigra* is included by ANDERSSON and other authors in sect. AMYGDALINAE (vel TRIANDRAE) together with *S. amygdaloides* And. In my opinion, *S. nigra* is much more closely related to *S. Humboldtiana* than to *S. amygdaloides* or any other species of sect. AMYGDALINAE. The species of sect. NIGRAE are exclusively American, and show no very close relationship to any other group of American willows or any section of those of the Old World. H. GÄRTNER (Vergl. Blattanatomie Gatt. Salix, Diss. Göttingen, 1907,

p. 22) apparently did not examine a true *nigra* because he does not mention the stomata in the upper surface of the leaf, but says "unterseits Stomaten und Wachsanflug." *S. nigra*, like *S. Humboldtiana*, possesses however "beiderseits Kutikularfalten und eine gleichgrosse Anzahl von Stomaten."

1. S. HUMBOLDTIANA Willd., Sp. Pl. **4**:657. 1805; Kunth in Humb. and Bonpl., Nov. Gen. Pl. **2**:18, *pls. 99, 100.* 1817; Syn. Pl. Aequin. **1**:364. 1822; Gay, Hist. Chile Bot. **5**:384. 1849; Leybold in Martius, Fl. Bras. **4**[1]:227. *pl. 71*, 1855; de la Sagra, Fl. Cubana **3**:232. 1853; Grisebach, Fl. Brit. W. Ind. Isl. 113. 1864; Philippi, Cat. Pl. Vasc. Chile, 267. 1881; Hieron., Pl. Diaph. Fl. Argent. 271. 1882; Fawcett, Prov. List Flow. Pl. Jamaica 37. 1893; Duss in Ann. Inst. Col. Marseille **3**:107 (Fl. Phan. Antill. Franç.). 1897; Macloskie in Princeton Univ. Exp. Patag. **8**[1]: Bot. 325 (Fl. Patag.) 1903–6; *S. magellanica* Poir. in Lam. Encycl. Suppl. **5**:66. 1817; *S. falcata* Kunth in Humb. and Bonpl., Nov. Gen. Pl. **2**:19. 1817, non Pursh; *S. Humboldtiana*, ***S. falcata* And. in K. Sv. Vet.-Akad. Handl. **6**:17 (Mon. Salic.). 1867; *S. Humboldtiana β falcata* And. in DC. Prodr. **16**[2]:199. 1868; *S. chilensis* Morong and Britton in Ann. N.Y. Acad. Sci. **7**:231 (Enum. Pl. Morong Paraguay). 1892, non Molina;[3] Seemen in Urban Symb. Antill. (Fl. Ind. Occ.) **4**:193. 1905; Fawcett and Rendle, Fl. Jamaica **3**:30. 1914.

TYPE LOCALITY.—"Peru, prope Loxam" (leg. *Humboldt* and *Bonpland*); this is Loja in southern Ecuador.

RANGE.—According to MORONG this willow "grows from the Amazon to Patagonia on both sides of the Andes." It is difficult to say where it is really spontaneous, because it has been widely distributed by cultivation. Although

[3] *S. chilensis* Molina, SAGGIO Storia Nat. Chili 169. 1782, is in my opinion an obscure plant. The author's quotation runs: "*Salix* fol. integerrimis glabris lanceolatis acuminatis," and in the Italian text he says: "Il Salce, *Salix chilensis* . . . . non differisce dall' Europeo, che nelle foglie, le quali sono intiere, sottili, e di un verde giahligno: questo albero produce una gran quantita di manna tutti gli anni. . . . ." Neither has *S. Humboldtiana* entire leaves, nor can I find any record of a willow producing "manna." The name *S. chilensis* seems to be accepted for our willow only because there is no other willow in Chile except the cultivated *S. babylonica* L. which had not yet been introduced at MOLINA'S time. I strongly suspect that MOLINA'S plant is no *Salix* at all. It is not mentioned by REICHE in his Productos Vegetales de Chile, 1901, nor in ENGLER and DRUDE, Veget. der Erde VIII (Grundzüge Pflanzenwelt Chile). 1907.

I have seen specimens from Argentine, Chile, Uruguay, Paraguay, Bolivia, Peru, Colombia, and southern Brazil I do not have a correct understanding of the wild habitat of this species, most of the material before me coming, apparently, from cultivated plants. I suppose *S. Humboldtiana* inhabits river valleys in the cold and temperate region from the Straits of Magellan to southern Brazil in the east and Ecuador in the west. Farther north, in Colombia and on the West Indian Islands, it seems to be only planted, but may occur sometimes escaped from cultivation. In Central America and in Mexico it is represented by var. *stipulacea*.

SPECIMENS EXAMINED.—I have not seen the type, which seems to be preserved in WILLDENOW's herbarium at Berlin, and I do not deem it necessary to enumerate here all the specimens I have seen because, as I have already said, most of them seem to be taken from cultivated plants.[4]

S. Humboldtiana is apparently a well marked species, and I deal with its relationship to *S. nigra* under var. *stipulacea*.

1b. S. HUMBOLDTIANA, var. **stipulacea** Schn., comb. nov.—*S. Houstoniana* Pursh, Fl. Am. Sept. **2**:614. 1814. quoad specim. Houstonianum ex Herb. Banks; *S. stipulacea* Mart. and Galeotti in Bull. Ac. R. Brux. **10**[1]:343 (Enum. Pl. Gal. Mex. 3) 1843; *S. Humboldtiana* ****S. oxyphylla* And. in K. Sv. Vet.-Akad. Handl. **6**:17 (Mon. Salic.). 1867, pro. parte; *S. Humboldtiana γ oxyphylla* And. in DC. Prodr. **16**[2]:199. 1868, pro parte; Bebb apud Smith Enum. Pl. Guat. part **2**:71. 1891; part **3**:76. 1893; *S. Humboldtiana* Mart. and Gal. in Bull. l. c. non Willd.; Hemsl. in Biol. Centr. Am. Bot. **3**:179. 1883, pro parte.

A typo praecipue recedit foliis non distincte linearibus sed pl. m. lineari-lanceolatis fere a basi ad apicem sensim attenuatis apice plerisque distinctius caudato-acuminatis et basi magis cuneato-attenuatis, stipulis saltem ramulorum validorum distinctius evolutis.

TYPE LOCALITY.—State Hidalgo, "au bord du Rio Grande de Mextitlan [Metztitlan] près du district de Real del Monte" (coll. *H. Galeotti*, no. 75, ex Martens and Galeotti).

RANGE.—This variety seems to reach its most northern point in Hidalgo, from where its range extends southward into Guatemala, Salvador, and Costa Rica, but I am not sure whether it is really spontaneous in the last two countries. It is probably also planted, together with the type, on the West Indian Islands.

[4] An enumeration of all the specimens I have examined will be given in the final publication of my studies on American willows.

SPECIMENS EXAMINED.—I have seen what I believe may be specimens from wild plants from the following states of Mexico: Hidalgo, Colima, Vera Cruz, Oaxaca, Tabasco, and Chiapas, and from the following Departments of Guatemala: Alta Verapaz, Izabal, Jalapa, Guatemala, Sololá, Amatitlan, and Zacatepequez.

The var. *stipulacea* is certainly very closely related to the typical *S. Humboldtiana*, but from the material before me I judge it to be a good geographical form which in some respect approaches *S. nigra*. The main difference between *S. Humboldtiana* and *S. nigra*, in my opinion, is the shape of the mature fruits which are ovoid-elliptical with a rather blunt apex in the first; while those of *S. nigra* and its varieties are more distinctly elongated and pointed at the apex, with mostly comparatively longer pedicels. Regarding the shape of the fruit, var. *stipulacea* has to be referred to *S. Humboldtiana;* the leaves, however, resemble more those of *S. nigra* var. *Lindheimerii*. There are indeed several forms in Hidalgo (namely, the specimens of C. S. PRINGLE from Tula, March 23, 1906) that need further observation in the field. They possess the glandular stipules of var. *Lindheimerii* and the fruits of var. *stipulacea*. In the state of Hidalgo the most southern forms of *S. nigra* seem to meet the most northern ones of *S. Humboldtiana*.

As to the nomenclature of the variety, the following may be said. Most of the authors used to refer it to *S. oxyphylla* Kth. in Humb. and Bonpl., Nov. Gen. Pl. **2**:19. 1817; Syn. Pl. Aequ. **1**:365. 1822, the type of which was collected by *Humboldt* and *Bonpland* "prope Chilpantzingo" (Chilpanzingo, in the state of Guerrero). Not having been able to compare a type specimen, nor having seen any specimen from near the type locality, I refrain from using the name *oxyphylla*, because in the description KUNTH makes the following statement: "semina minuta, oblonga, lanata; stipite dimidiam vix lineam longo, pubescente." The whole seed being hardly half a line long and having no "stipes," the statement seems to indicate a pubescent pedicel of the ovary, but I have not met with such a form. I regard *S. oxyphylla* as an uncertain name, therefore, and I accept the name *stipulacea* given by MARTENS and GALEOTTI to a form that differs from *S. Humboldtiana* by its persistent stipules and its more sharply acuminate leaves.

1c. S. HUMBOLDTIANA, var. MARTIANA And. in DC. Prodr. **16**^{2}:199. 1868.—*S. Martiana* Leybold in Martius, Fl. Bras. **4**^{1}:228. *pl. 72*. 1855; in Walp. Ann. Bot. **5**:757. 1858; Huber in Bull. Herb. Boiss. II. **6**:253. 1906, in adnot.; *S. Humboldtiana* **S. Martiana* And. in K. Sv. Vet.-Akad. Handl. **6**:18 (Mon. Salic.). 1867.

Varietas porro observanda a typo praecipue differre videtur floribus femineis glandula etiam dorsali (an semper?) instructis, fructibus ellipticis utrinque pl. m. obtusis paullo majoribus.

TYPE LOCALITY.—"In omni ripa et in insulis sabulosis flum. Amazonum a Gurupà (prov. Para in Brasilia) at Peruviam usque frequens."

RANGE.—This variety seems to be confined to the territories of the Amazon and Solimoes River in Brazil, and probably in the adjacent part of Colombia.

SPECIMENS EXAMINED.—Brazil; Prov. Para, "in vicinibus Santarem," July 1850, *R. S. Spruce* (fr.; G.);[5] Lower Amazons, Prainha, marshy beach, November 18, 1873, *I. W. H. Traill* (no. 717, fr.; G.)—Colombia (?), without locality (Herb. Lehmannianum, B.T. 1261, f., fr.).

The material before me is much too scanty to judge the value of this variety. The main characters by which it may be separated from typical *S. Humboldtiana* seem to be the presence of a dorsal gland in the pistillate flowers and the more elliptical shape of the somewhat larger capsules. In SPRUCE's specimen two of the otherwise normal leaves are broadly lanceolate, the larger being about 21 mm. wide. LEYBOLD gives as another distinguishing character the hairy pedicels which, however, are glabrous on the specimens before me. This form needs further investigation.

2. S. NIGRA Marsh., var. **Lindheimerii** Schn., nov. var.—*S. Humboldtiana*, γ *oxyphylla* And. in DC., l. c. 199, quoad specim. Berlandierii no. 2317, 3026; *S. nigra* Mackensen, Trees Shrubs San Antonio 14. 1909, non Marsh.; *S. Wrightii* Sargent, Trees and Shrubs **2**:215. 1913, quoad specimina texana, non And.; *S. Humboldtiana* Blankinship in Rep. Miss. Bot. Gard. **18**:194. 1907, non Willd.

Arbor ad 15–20 m. alta, trunco ad 0.75 m. crasso, cortice cinereo-brunnescente rugoso; ramuli novelli pl. m. pilosi vel villosuli, cito glabrescentes vel glabri, hornotini olivacei vel flavo-brunnei, annotini brunnescentes, dein cinereo-brunnei vel cinereo-fusci, satis graciles tenuesque, teretiusculi; gemmae ovatae, acutiusculae, petiolis subtriplo breviores, apice divaricatae. Folia adulta satis firma, linearia, lineari-lanceolata vel majora anguste lanceolata, ramulorum principalium steriliumque[6] (inferioribus

[5] I am using the following abbreviations: G., Gray Herbarium; M., Herbarium Missouri Botanical Garden; N., Herbarium New York Botanical Garden; W., U.S. Nat. Herbarium, Washington, D.C. If there is no indication of a herbarium the specimens are in A., the herbarium of the Arnold Arboretum (and mostly also in the other herbaria); also, m., male specimen; f., female specimen in anthesis; fr., fruiting specimen (im. fr. means with immature fruits); st., sterile specimen.

[6] I distinguish 3 different kinds of leaves: (1) those of the ends of main and sterile branchlets and of vigorous shoots (offshoots and suckers), which usually represent the typical mature leaves toward the end of the season; (2) those of the lower parts of these parts, representing the leaves of the first season's growth which are

exceptis) basi sensim in petiolum attenuata, ab infra medium ad apicem sensim acuminata, apice satis longe caudata, saepe falcata, 7:0.3 vel 8:0.6 ad 12:0.7 vel 15:1.2 cm. magna, inferiora saepe lineari-elliptica, utrinque obtusiora vel obtusa, ramulorum fertilium (pedunculorum) variabilia, saepe elliptico-linearia vel anguste elliptica, utrinque acuta vel obtusiora, 2:0.3 ad 6–7:0.7–0.9 cm. magna, superne tantum valde initio sparse puberula et citissime glabrescentia, vivide viridia, ut in *Humboldtiana* reticulata et nervo intra-marginali percursa, subtus concoloria, initio ut superne vel saepe paullo magis pilosa, dein glaberrima, eodem modo reticulata, margine satis dense aequaliter glanduloso-serrato-denticulata vel in foliis inferioribus ramulorum fertilium indistinctius dentata vel interdum subintegerrima. Petioli quam in *S. nigra* pl. m. longiores, latitudinem maximam laminae plerique superantes, 2–10 mm. longi. Stipulae satis rariter distincte evolutae, iis formae typicae similes sed intus in facie pl. m. glanduliferae, vix ultra 8 mm. longae. Amenta fere ut in forma typica sed saepissime magis laxiflora, mascula ad 7:0.8 cm. magna; stamina 3–7, filamentis ad medium vel paullo ultra dense villosis; bracteae ovatae vel ovato-oblongae, pl. m. acutae, rarius obtusae, utrinque villosulae vel extus ultra medium ad apicem glabrescentes; glandulae 2, dorsalis pl. m. 3-partita (digitata); amenta feminea fructifera 4–7:1.3 cm. magna (pedunculis foliatis interdum ad 4 cm. longis exclusis), pl. m. laxiflora; bracteae ovato-oblongae, pl. m. acutae, interdum ad apicem parce denticulatae, ut in floribus masculis villosae; ovaria stigmataque ut in *S. nigra* typica; glandula 1, ventralis, pl. m. ovata-rectangularis, apice truncata, pedicello juvenili duplo brevior; fructus maturi (5–)6–7 mm.

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mostly of a different shape, and often more resemble those of the fertile branchlets; and (3) those of the fertile branchlets, that is, of the peduncles or the branchlets terminated by the catkins. It seems to me very helpful to keep apart those 3 different kinds of leaves, of which as a rule only one or two are represented in a specimen. Therefore, every collector of willows should try to get, at different times of the year, if possible from the same plant and of both sexes, the following parts: (1) branchlets with young flowers; (2) branchlets with ripe fruits collected when the first capsules begin to open; (3) mature leaves collected toward the end of the season (end of August to end of September, except in subtropical climates); (4) parts of offshoots with mature and young leaves; (5) leafless branchlets in winter with good buds, and pieces of bark.

longi, iis formae typicae similes sed basi pl. m. subito attenuati, pedicellis satis tenuibus 2–3plo brevioribus glandulam siccam 4–6plo superantibus suffulti.

TYPE LOCALITY.—Texas, Comal County, on the Guadalupe River (leg. *Lindheimer*, no. 415).

RANGE.—Eastern and southeastern Texas (perhaps also in southern Oklahoma), from about 34° N. lat. and between 100 and 95° W. long. southward into Mexico to southeastern Coahuila, Nuevo Leon, and to Tamaulipas (and probably also Hidalgo).

SPECIMENS EXAMINED.—Texas: Comal County, New Braunfels, on the Guadalupe and other rivers, 1850, *F. Lindheimer* (no. 415, m., f., fr., type!; G., M.; in the Gray herbarium named by ANDERSSON himself *S. nigra* var. *angustifolia;* it is the same as no. 1189 distributed by the Mo. Bot. Gard. as *S. Humboldtiana*).—Mexico: State of Tamaulipas: Matamoros, March 1836, *J. J. Berlandier* (no. 3026, fr.; sub nomine inedit. "S. viridis"; G., M.); without exact locality (perhaps from Texas), *J. J. Berlandier* (no. 854, st.; M.; no. 887, fr.; G., M.; no. 2274, st.; G., M.; no. 2317, fr.; G., M.); vicinity of Victoria, alt. about 320 m., February 1—April 9, 1907, *E. Palmer* (no. 134, m.; M., W.).—State of Nuevo Leon: Monterey, May 1891, *C. K. Dodge* (m., fr.; W.; forma porro observanda); same locality, common, March 19–20, 1900, *C. S. Sargent* (m., f.; "large tree"); same locality, March 18–19, 1900, *W. M. Canby* (nos. 231, f., 232, m.; G., W.); same locality, March 18, 1900, *W. Trelease* (no. 131, f.; M.).—State of Coahuila:[2] Ciudad Porfirio Diaz, April 8, 1900, *W. Trelease* (no. 133; M.; fructibus juvenilibus ad *S. Humboldtianam* spectans); Saltillo, April 15–30, 1898, *E. Palmer* (no. 27, m.; "tree of 30 ft. or more high, rather rough bark, not seen over 1 ft. in diam., about watercourses and cultivated places, indicating artificial planting"); mts. 6 miles east of Saltillo, April 1888, *E. Palmer* (no. 1286, m.; G., W.); Pueblo near Saltillo, March 18, 1847, *J. Gregg* (no. 296, m.; M.); San Bernardo or "Green Spring," April 8, 1847, *J. Gregg* (no. 470, m., fr.; M.).

This willow, which has hitherto been regarded either as *S. nigra* or *S. Humboldtiana*, seems to me to represent the most southern form of *S. nigra*. It is not always easy to separate it from typical *nigra* from northern Texas, but the leaves are usually narrower or at least more attenuated at the base, with a comparatively much longer petiole. The young branchlets and the petioles are glabrous or become so very soon, while those of *S. nigra* and its southeastern var. *altissima* Sarg. are, for some time at least, more or less distinctly puberulous or villose. Moreover, the stipules of var. *Lindheimerii* bear always some

[2] There is a specimen collected by C. G. PRINGLE, Jimulco, by streams, alt. 1300 m., October 10, 1905 (no. 10086½, fr.; G.; "a medium sized tree"), bearing only short dense aments (1–2.5:1 cm.), with small, linear-lanceolate, almost entire leaves (about 2–3:0.4–0.5 cm.) on the short peduncles which, I believe, has to be referred to var. *Lindheimerii*.

minute yellowish glands upon the inner surface, which are absent in the typical black willow and var. *altissima*. The fruits of var. *Lindheimerii* are somewhat larger (6–7 mm. long) than those of the typical form (4–5 mm.). On the other hand, the Mexican specimens are often very similar to those of *S. Humboldtiana*, var. *stipulacea;* from this var. *Lindheimerii* seems to be best distinguished by its looser fruiting catkins, its more elongated fruits with longer and thinner pedicels, its leaves being more distinctly attenuated at the base, and by its comparatively longer petioles.

There are the following specimens from western Mexico which may represent a distinct form of var. *Lindheimerii* or a new variety of *S. nigra*. From a geographical point of view one might expect those plants to be a form of *S. Gooddingii*, but the color of the older branchlets, although being not quite so reddish brown as in var. *Lindheimerii*, is much more like it than *S. Gooddingii*. I do not dare to propose a new variety, but I want to draw the attention of collectors to it in the hope that they may be able to procure good flowering material, ripe fruits, and mature leaves.

Mexico: State of Sinaloa, vicinity of Guadalupe, April 18, 1910, *J. N. Rose, P. C. Standley*, and *P. G. Russell* (no. 14780, st.; W.; folia lineari-lanceolata iis var. *Lindheimerii* simillima, ad 13 cm. longa et 9 mm. lata, basi valde acuta, petiolis gracilibus fere ad 1 cm. longis); vicinity of Villa Union, moist field, April 2, 1910, same coll. (no. 13955, m., N., W.; folia ut in praecedente, amenta parva, vix 2.5:0.6 cm. magna; bracteae versus apicem amenti acuminatae, basim versus obtusiores; pedunculi vix 1 cm. longi, folia plura linearia ad 3 cm. longa gerentes); vicinity of Culiacan, April 21, 1910, same coll. (no. 14803, f., st.; N., W.; folia maxima ad 13:1.4 cm. magna, petiolis ad 15 mm. longis; flores ut in var. *Lindheimerii;* fructus immaturi circ. 5 mm. longi pedicello duplo breviore).—Terr. Tepic, Santiago, February 1895, *F. H. Lamb* (no. 581, f.; G., M., N.; a var. *Lindheimerii* praecipue differt bracteis florum juvenilium acuminatis et pubescentia distinctiore ramulorum novellorum; amenta valde laxiflora, ad 8 cm. longa, fructibus nondum maturis); vicinity of Acaponeta, April 11, 1910, *Rose, Standley*, and *Russell* (no. 14362, st.; N., W.; ramuli hornotini flavescentes, ceterum ut in var. *Lindheimerii*).

3. S. GOODDINGII Ball in BOT. GAZ. **40**:376, *pl. 12, figs. 1, 2*. 1905. —*S. nigra* Bebb in Watson, Bot. Calif. **2**:83. 1879, non Marsh.; Jepson, Fl. Cal. **2**:339. 1909; Parish, Cat. Pl. Salton Sink 3. 1913 (reprinted from "The Salton Sink," Publ. no. 93, Carnegie Inst. Wash.); Wooton and Standley in Contrib. U.S. Nat. Herb. **19**:161 (Fl. N.Mex.). 1915; *S. nigra*, var. *vallicola* Dudley apud Abrams, Fl. Los Angeles 100. 1904; Suppl. Ed. 100. 1911; *S. vallicola* Britt., N.Am. Trees 184. *fig. 141*. 1908; *S. Wrightii* Woot. and Standl. in Contrib. l. c. 160. 1915, non And.

TYPE LOCALITY.—Southeastern Nevada, Clark County, Muddy Creek (coll. *Goodding*, no. 689, f.; forma satis abnormalis ab insectis infecta).

RANGE.—California, southeastern Nevada, Arizona, southwestern New Mexico (probably also east of the Rio Grande and even in southern Colorado), and northern Mexico (Chihuahua, Sonora, northern Sinaloa, northern Lower California).

SPECIMENS EXAMINED (from Mexico).—Lower California: Gardner's Laguna, April 21, 1894, *L. Schoenfeldt* (no. 2895, st.; W.); Seven Wells, on the Salton River, April 8, 1894, *E. A. Mearns* (no. 2869, m.); along Hardy River, April 3, 1905, *D. McDougal* (no. 100, f.; N.; "small tree").—State of Sonora: Sonora shore of Colorado River near International Boundary, March 27, 1905, *D. McDougal* (no. 90, m.; N.; "tree 30–40 ft."); Colonia Diaz, May 29, 1894, *E. A. Mearns* (no. 2840, m.; G., M., N., W.); La Chumata, alt. 1330 m., May 29, 1905, *W. W. Brown* (st.); vicinity of Magdalena, April 25, 1910, *J. N. Rose, P. C. Standley*, and *P. G. Russell* (no. 15113, fr.; W.); vicinity of Hermosillo, bed of Rio de Sonora, March 5, 1910, same coll. (no. 12391, fr.; N., W.; "5 ft. or less"; forma porro observanda pedicellis fructuum subbrevioribus); along irrigating ditches, March 7, 1910, same coll. (no. 12501, m., f.; W.; forma porro observanda); vicinity of Navojoa, March 21, 1910, same coll. (no. 13156, fr.; N., W.; ut praecedens).—State of Chihuahua: along the Rio Grande near Ciudad Juarez, 1911, *E. Stearns* (fr.; N.; mixed with male *S. exigua*, var. *stenophylla*); vicinity of Chihuahua, alt. about 1300 m., April 8–27, 1908, *E. Palmer* (nos. 41, f., 42, m.; N.; forma porro observanda); Santa Eulalia Mts., April 1885 (♂?), *Wilkinson* (m.; W.); Lake Palomas, Mimbres Valley, April 14, 1892, *E. A. Mearns* (no. 184, f.; W.; also no. 183 in 1892 without exact locality, fr.; N.).—State of Sinaloa, vicinity of San Blas, March 24, 1910, *Rose, Standley*, and *Russell* (no. 13415, f., fr.; N., W.).

C. R. BALL, in describing *S. Gooddingii* from rather poor female specimens, mistook it for a species of sect. LONGIFOLIAE. Later he recognized, as he has told me, the identity of his species with *S. nigra* var. *vallicola* Dudl. (*S. vallicola* Britt.). According to the international code the name *S. Gooddingii* has to be used if this willow is considered a distinct species. It certainly is a good species, and very different from the eastern *S. nigra*, which always has more or less reddish brown or purplish branchlets. Otherwise, the western species is closely related to *S. nigra*, and is clearly a member of the same section.

Sect. II. TRIANDRAE Dumortier in Bijdr. Natuurk. Wetensch. **1**:58 (Verh. Gesl. Wilgen 17). 1825; Borrer in Hooker, Brit. Fl. 414. 1830; in Loud., Arb. Frut. Brit. **3**:1496. 1838, excl. *S. lucida*.—Sect. AMYGDALINAE W. D. Koch, Salic. Eur. Comment. 17. 1828, pro parte; Andersson in K. Sv. Vet.-Akad. Handl. **6**:19 (Mon. Salic.). 1867, pro parte; in DC. Prodr. **16**^{2}:200. 1868, pro parte; Ball in Coult. and Nels., New Man. Rocky Mt. Bot. 129. 1909, excl. *S. nigra*.

In my opinion, *S. amygdaloides* And. is the only American willow which belongs to this section. It seems to be more closely related to the European-Asiatic *S. amygdalina* L. than to *S. nigra* with which it is usually associated in the same section by authors.

4. S. AMYGDALOIDES, var. **Wrightii** Schn., comb. nov.—*S. Wrightii* And. in Oefvers. K. Vet.-Akad. Förh. **15**:115 (Bidr. Känned. Nordam. Pilart.). 1858; in Proc. Amer. Acad. **4**:55 (Sal. Bor.-Am. 9). 1858; in Walp., Ann. Bot. **5**:745. 1858; *S. nigra* ****S. Wrightii* And. in K. Sv. Vet.-Handl. **6**:22. 1867; *S. nigra* b. *latifolia* γ *brevifolia testacea* And., l. c. 21; *S. nigra* δ *Wrightii* And. in DC. Prodr. **16**[2]:201. 1868; Hemsl. in Biol. Centr. Am. Bot. **3**:180. 1883, quoad Wright 1877[8]; Bebb in Bot. Gaz. **16**:102. 1891; *S. testacea* And., in Prodr. l. c., pro synon. *S. nigrae* formae 3.

TYPE LOCALITY.—Western Texas, El Paso County, or, according to WOOTON and STANDLEY, Mexico, state of Chihuahua, on the Upper Rio Grande or from Lake Santa Maria (coll. *C. Wright* no. 1877).

RANGE.—Western Texas near the border of Mexico and probably adjacent Mexico, northern New Mexico (and ? southern Colorado).

SPECIMENS EXAMINED.—Besides C. Wright's nos. 1876 and 1877, which may have been collected in Chihuahua in the places mentioned above, I have not seen any specimen from Mexico.

Judging by the material before me, *S. Wrightii* seems to be hardly more than a variety of *S. amygdaloides*, from which it differs chiefly in its more distinctly yellowish branchlets, its more lanceolate and more gradually acuminate leaves which always possess numerous stomata in the upper epidermis. It is certainly not a "mere forma monstrosa" as BEBB suggested in Gard. and For. **8**:363. 1895; and as is stated even by BALL in Coult. and Nels., New Man. Rocky Mt. Bot. 129. 1909, who, however, regards it now as a good species. The type specimen, *Wright* no. 1877, shows short, dense, and indeed not quite normal fruiting aments, which when well developed measure up to 10 cm. in length. *Wright* no. 1876, the type of what ANDERSSON called *S. nigra latifolia brevifolia testacea*, a specimen with male and female flowers and very young leaves, has been erroneously regarded by some authors as being the same as *S. nigra longipes venulosa* And. The type of this form which I have not seen from Mexico is *Wright* no. 1879. It represents the southwestern variety of *S. longipes* Shuttl. (*S. occidentalis* Bosc apud Koch, non Walter) and has to be called *S. longipes*, var. **venulosa** (And.) Schn., n. comb.

[8] The second specimen mentioned by HEMSLEY, which had been collected by *Jurgensen* (no. 307) in the "Sierra San Pedro Nolasco" (? state of Oaxaca), does not belong to our variety, but I have not seen it.

Sect. III. BONPLANDIANAE Schn., sect. nov.—Sect. AMYGDALINAE And. in K. Sv. Vet.-Akad. Handl. **6**:19 (Mon. Salic.). 1867, pro parte; in DC. Prodr. **16**^{2}:200. 1868, pro parte.—Arbores vel frutices alti. Folia mediocra vel satis magna, pleraque anguste vel late lanceolata vel elliptico-lanceolata, adulta crasse papyracea, superne non stomatifera. Amenta coetanea vel serotina, mascula brevi-pedunculata vel rarius sessilia, cylindrica, interdum satis longa, densi- vel sublaxiflora, floribus pleiandris, staminibus 3–7(–11), antheris pl. m. globosis, glandulis 2, saepe lobulatis vel partitis et pseudodiscum formantibus rarius distinctis dorsali interdum parva; amenta feminea pleraque longius pedicellata, fructifera saepe elongata, pleraque densiflora; ovaria longe (rarius breviter) pedicellata, glabra vel (saltem partim) pilosa; styli breves vel brevissimi, stigmatibus satis brevibus clausis vel emarginatis; glandula una ventralis, saepe lata, truncata et satis crassa, interdum basim pedicelli subamplectens.[9]

The species united by me in this section form a very distinct group of the American PLEIANDRAE. They are closely related among each other, but well separated from the other sections of the PLEIANDRAE either in America or in the Old World. In some respects they somewhat resemble the species of sect. TETRASPERMAE And. sensu SCHNEIDER in Sargent, Pl. Wilson **3**:93. 1916, but I am far from assuming that there may be a close relationship between those two sections. A main difference between the species of sect. BONPLANDIANAE and most of the other American PLEIANDRAE is the complete absence of stomata in the upper surface of the

[9] With regard to these glands the following is to be said. In SARGENT, *Silva N. Am.* **9**:120. 1896, we find the statement that *S. Bonplandiana* (var. *Toumeyi*) has a "cup-shaped disk," and that it is the only willow of the United States with a cuplike disk. Besides this, SARGENT says that this disk "is not represented in ANDERSSON's figure" (Mon. Salic. *pl. 1, fig. 14*), but in ANDERSSON's *fig. 14, d* the disk is well shown. Referring to the figure given in SARGENT (*pl. 472*), TOEPFFER (Österr. Bot. Zeit. **54**:175. 1904) says that there is in *S. Bonplandiana* "ein vollkommen becherförmiger Torus, wie bei der Gattung *Populus*." This is, however, not the case. After having investigated the flowers of the specimens mentioned above, I find that there is only a large and broad ventral gland which sometimes almost entirely encircles the base of the pedicel, but mostly there is a distinct lack of a dorsal gland. The very same conditions may be observed in specimens of the typical *S. longipes* Shuttl. from Florida. The broad, half-embracing ventral gland is very rarely nearly cup-shaped and somewhat similar to the cuplike torus of *Populus*.

leaves. Probably all the other PLEIANDRAE possess such stomata, but sometimes they are so sparse that it is difficult to detect them.

5. S. JALISCANA Jones, Contrib. West. Bot. **12**:77. 1908.—Ad descriptionem addenda et emendanda: Frutex ut videtur altus; truncus?; ramuli novelli dense griseo- vel subferrugineo-villosulo-tomentosi, annotini fuscescentes, laxius vel tantum partim tomentosuli, vetustiores fusco-cinerascentes, glabrescentes. Gemmae bene evolutae non visae, ut videtur glabrae. Folia matura perfecte evoluta a me non visa, semievoluta (in specimine femineo) inferiora ovali-elliptica vel elliptico-obovata, superiora majora elliptica vel elliptico-lanceolata, basi obtusa rotundave, apice acuta vel summo breviter acuminata, inferiora ut videtur satis evoluta (minimis exceptis) 3.5:1.5 ad 5.5:2.3 cm. magna, superiora ad 7:2.5 vel 8:1.7–2 cm. magna, in speciminibus masculis pleraque angustiora, interdum oblanceolata, 3:0.7 ad 8:1.5 cm. magna, superne initio pl. m. sericeo-villosa, cito glabrescentia, adulta probabiliter glabra vel tantum in costa flavescente plana pl. m. pubescentia, intense viridia, subtus valde discoloria, initio dense griseo- vel ferrugineo-villosa, dein glabrescentia, glaucescentia, pruinosa, costa nervisque lateralibus utrinsecus ad 12 angulo 60–45° a costa abeuntibus versus marginem currentibus pl. m. prominulis flavescentibusque, margine pl. m. dense subdistincte glanduloso-serrato-denticulata, versus basim integerrima. Petioli 1–8 mm. longi, superne sulcati, undique villoso-tomentelli. Stipulae parvae, lineari-lanceolatae, subglabrae, denticulatae, petiolis 2–3plo breviores, cito deciduae. Amenta tardiva, ramulos normaliter foliatos 1–2 cm. longos terminantia, rhachi villosa; mascula cylindrica, ad 3.5:0.8 cm. magna, densiflora; bractae obovatae vel late ovato-oblongae, obtusae vel rotundatae, flavescentes, utrinque villosae vel apicem versus glabrescentes, 2–3.5 mm. longae; stamina pleraque 5, filamentis ad medium fere villosis, antheris flavis elliptico-globosis; glandulae 2, pl. m. lobatae, rarius simplices; amenta feminea semimatura ad 4.5 cm. longa et 1.3–1.5 cm. crassa, cylindrica vel elliptico-cylindrica, fructibus valde congestis; bracteae late oblongae, obtusae, villosulae, apice glabriores, pedicellum paullo vel vix superantes; ovaria semimatura (juvenilia ignota) ovoideo-conica, basi subacuta, apice obtusa, circ. 4 mm.

longa, basi et pedicello subcrasso iis subduplo breviore pilosa, ceterum glabra, stylo brevi stigmatibus brevibus subbifidis satis latis vix longiore coronata; glandula 1, late ovato-rectangularis, quam pedicellus 3(–4)plo brevior, satis crassa.

TYPE LOCALITY.—Mexico: State of Jalisco, Ferreria, and Sierra de Nayarit.

RANGE.—As above, possibly also in Terr. Tepic, to which part of the Sierra de Nayarit belongs (probably also in the state of Michoacan, see note below).

SPECIMENS EXAMINED.—Mexico: State of Jalisco, Sierra de Nayarit, without date, *Léon Diquet* (male paratype; N.); Ferreria, May 28, 1898 (2?), *M. E. Jones* (no. 437; female type of description, probably also co-type of Jones, who gives no number and as year 1892; M.); without any locality or date, *G. H. G[raham]*[10] (m., ex Herb. J. S. Mill in Herb. G.; identical with Diquet's specimen).

The specimens before me agree well with JONES's description, who collected only the female plant. No. 437 is very likely the same as the plant cited by him as type. It seems to me more closely related to *S. Bonplandiana* or *S. longipes* than to *S. laevigata* mentioned by JONES. Unfortunately, there are no fully grown leaves; the largest I have seen resemble those of *S. longipes*. In size and shape of the female aments and of the fruits it comes very near *S. Bonplandiana*. The male aments are remarkably small and fine, hardly as long or longer than the narrowly lanceolate leaves of the peduncle.

6. S. BONPLANDIANA Kunth in Humboldt and Bonpland, Nov. Gen. Pl. **2**:20. *pls. 101, 102.* 1817; Syn. Pl. Aequin. **1**:365. 1822; Martens and Galeotti in Bull. Acad. R. Bruxelles **10**[1]:343 (Enum. Pl. Galeot. Mex. 3). 1843; Andersson in K. Sv. Vet.-Akad. Handl. **6**:18, *pl. 1, fig. 14* (Mon. Salic.). 1867, excl. var.; in DC. Prodr. **16**[2]:200. 1868, excl. var.; Hemsley in Biol. Centr. Am. Bot. **3**:179. 1883, excl. var.; Brandegee in Proc. Cal. Acad. Sci. II. **3**:173. 1891; Wooton and Standley in Contrib. U.S. Nat. Herb. **19**:161 (Fl. N.Mex.). 1915; Goldman in Contrib. l. c. **16**:320. 1916.

TYPE LOCALITY.—"In regno Mexicano locis opacatis prope Moran, Cabrera, Omitlan et Pachuca,[11] alt. 1270–1350 hexap." (coll. *Humboldt* and *Bonpland*, ex Kunth).

[10] According to BENTHAM, Pl. Hartw. preface p. 4. 1839, GRAHAM collected "about the town of Mexico and in the mining district of Tlalpuxahua and Real del Monte." Tlalpuxahua is in the state of Michoacan, 50 miles east of Morelia.

[11] These localities are probably all in the state of Hidalgo; see Humb. and Bonpl., Nov. Gen. Pl. **7**:341. 1825.

RANGE.—The typical form extends from the southwestern corner of New Mexico through the states of Chihuahua, Durango, southern Coahuila, southern Lower California, to Oaxaca and Vera Cruz, and probably farther south in Mexico, because the species occurs again in Guatemala (see below); see also under var. *Toumeyi*.

SPECIMENS EXAMINED.—New Mexico: Grant County, Canyon east side of San Luis Mountains, September 11, 1893, *E. A. Mearns* (no. 2189, m.; M., N.).—Mexico: State of Chihuahua, Canyon below Cusihuiriachic, September 21, 1888, *C. G. Pringle* (no. 2003, m., fr.); in the Sierra Madre near Seven Star Mine, alt. 2300 m., September 4, 1899, *C. H. T. Townsend* and *C. M. Barber* (no. 405, f., fr.; G., M.; forma porro observanda, an ad var. *Toumeyi* referenda?).—State of Coahuila, Jaral, [?June] 10, 1886, *W. Schumann* (no. 1318, m.; W.).—State of Durango, vicinity of Durango, [autumn] 1896, *E. Palmer* (no. 636, f., fr.).—Lower California, near Creek San Pablo, alt. 180–220 m., January–March 1898, *C. A. Purpus* (no. 140, m., fr.; W.); from El Saccaton to Cape San Lucas, alt. 10–150 m., December 29, 1905, *E. W. Nelson* and *E. A. Goldman* (no. 7373, m.; W.); from Miraflores to San Bernardo Ranch in Sierra La Laguna, alt. 450 m., January 20, 1906, same coll. (no. 7419, m.; W.).—State of San Luis Potosi, "ex convalli San Luis Potosi," 1877, *J. G. Schaffner* (no. 263, f.; N.).—State of Hidalgo, Tula, river banks, alt. 2000 m., August 18, 1906, *C. G. Pringle* (no. 13788, m., f.; G., W.).—State of Queretaro, near San Juan del Rio, August 18, 1905, *J. N. Rose*, *J. H. Painter*, and *J. G. Rose* (no. 9600, fr.; N.).—State of Guanajuato, Guanajuato, September and November 1897, *A. Dugès* (m., fr.; G., W.).—State of Jalisco, Guadaljara, February 28, 1907, *W. E. Safford* (no. 1425, st.; W.; "an important tree planted for shade"); near Tequila, July 5–6, 1899, *J. N. Rose* and *W. Hough* (no. 4768, im. fr.; W.).—State of Michoacan, valley near Zinapecuaro, east of Morelia, May 2, 1849, *J. Gregg* (no. 767, st.; M.; "tree 30 ft. high"); wet places near Patzcuaro, November 20, 1890, *C. G. Pringle* (no. 3376, m., f.).—Federal District, "Vallée de Mexico," June 18, 1865, *E. Bourgeau* (no. 423, m., f.; G., W.); same locality, alt. 2200 m., August 17, 1901, *C. G. Pringle* (no. 9337, m., f., fr.; G., M., W.); also August 12, 1899, *C. G. Pringle* (no. 7916, m., f.; G.; "small tree"); without exact locality, September 16, 1910, *C. R. Orcutt* (no. 4070, m.; M.); without any locality but probably in this district, *G. J. G[raham]* (m.; G.).—State of Morelos, by streams near Cuernavaca, alt. 1500 m., August 14, 1906, *C. G. Pringle* (no. 10284, m., f.; G., M., W.); also June 9, 1904, *C. G. Pringle* (no. 13203, m., f., fr.; G., W.).—State of Puebla, Tehuacan, *H. Galeotti* (no. 67, m.; N.).

The typical *S. Bonplandiana* is a well marked species which produces its flowers in the axils of the mature leaves from July to January, the old leaves not falling off until the new growth starts. This habit gives the species a peculiar appearance, but cannot be regarded as a valuable taxonomic character because it seems due to climatic conditions. The following specimens from Guatemala, therefore, hardly represent a different variety but only a

form the flowers of which appear with the development of the young leaves. Nevertheless, this most southern form of *S. Bonplandiana* needs further observation. The young twigs and the upper surfaces of the young leaves show a scanty pubescence of rather long downy silky hairs. TUERCKHEIM's specimens have been regarded as belonging to *S. laevigata* by BEBB, but in my opinion they are much more similar to *S. Bonplandiana* than to the other species.

Guatemala: Dept. Alta Verapaz, "am Cobanflusse bei Coban," alt. 1360 m., February 1886, *A. v. Tuerckheim* (no. 333, m., f.; G., W.; ab J. D. SMITH sub nomine *Humboldtiana falcata* distributa, praeterea a cl. BEBB *S. laevigata* nominata); same place, alt. 1360 m., November 1907, *A. v. Tuerckheim* (no. II. 1526, f., fr.; G., M., W.; eadem forma ac no. 333 sed folia novella superne laxe sericeo-villosa cito glabrescentia).—Dept. Baja Verapaz, between Tactic and Salancá, June 5, 1904, *O. F. Cook* (no. 217, st.; W.)—Dept. Huehuetenango, roadside near Huehuetenango, alt. 1950–2600 m., January 10–11, 1896, *E. W. Nelson* (no. 3677, m.; W.).—Dept. Solalá, San Lucas, February 15–16, 1906, *W. A. Kellerman* (nos. 5693, 5819, st.; W.); Volcano of Santa Maria, alt. 2600–3500 m., January 24, 1906, *E. W. Nelson* (no. 3725, f., fr.; G., W.).—Dept. Sacatepequez, Santa Maria de Jesus, cult. in hedge, February 18, 1905, *W. A. Kellerman* (no. 4528, st.; W.).

6b. S. BONPLANDIANA, var. PALLIDA And. in DC. Prodr. **16**[2]: 200. 1868; Hemsley in Biol. Centr. Am. Bot. **3**: 179. 1883; Brandegee in Proc. Cal. Acad. Sci. II. **2**: 205. 1889, fide auctor; Bebb apud Vasey and Rose in Contrib. U.S. Nat. Herb. **1**: 77. 1890.—*S. pallida* Kunth in Humb. and Bonpl., Nov. Gen. Pl. **2**: 20. 1817; *S. Bonplandiana* **S. pallida* And. in K. Sv. Vet.-Akad. Handl. **6**: 18 (Mon. Salic.). 1867.

A typo nonnisi recedit ramulis novellis petiolisque satis vel parce villosulis foliis etiam saepe ad costam pl. m. pilosis.

TYPE LOCALITY.—"In calidis regni Novae Hispaniae inter Venta de Acaguisotla et Masatlan[12]) alt. 500–650 hexap." (coll. *Humboldt* and *Bonpland*, ex Kunth).

RANGE.—Central Mexico (probably also in Lower California).

SPECIMENS EXAMINED.—State of San Luis Potosi, without exact locality, 1877, *J. G. Schaffner* (no. 263, f.; W.); "in locis cultis circa urbem San Luis Potosi," 1876, *J. G. Schaffner* (no. 895 partim, f.; G.; mixed with sterile specimen of *S. Humboldtiana* var. *stipulacea*).—State of Puebla, Atlixco, July 25, August 1, 1893, *E. W. Nelson* (m.; W.; ramulis tantum apice parce pilosis).—State of Jalisco, near Huejuquilla, August 24, 1897, *J. N. Rose* (no. 2535, m.;

[12] These localities which I cannot find on the maps at my disposal seem to be in the state of Guerrero according to Humb. and Bonpl., Nov. Gen. Pl. **7**: 341. 1825.

W.; ut praecedens).—State of Oaxaca, Valle de Etla, alt. 1580 m., April 1906, *C. Conzatti* (no. 1721, fr.; W.).

It is on the authority of ANDERSSON that I refer these specimens to var. *pallida*. Without having seen a type specimen I cannot decide whether KUNTH's species really represents a variety of *S. Bonplandiana*. The specimens before me are in my opinion nothing but a more or less pubescent form and hardly deserve the rank of a variety. The geographical distribution is probably the same as that of the species. Almost every species of the American PLEIANDRAE breaks up in a hairy and a glabrous variety which sometimes look very different, but mostly seem to be connected by every grade of intermediate forms.

6c. S. BONPLANDIANA, var. **Toumeyi** Schn., var. nov.—*S. Bonplandiana* Bebb in Gard. and For. **8**:364. 1895, non Kunth; Sargent N.Am. Silva **9**:119. *pl. 472*. 1896, exclud. syn. pro parte max.; *S. Toumeyi* Britton, N.Am. Trees 187, *fig. 145*. 1908; *S. Humboldtiana* Sarg. ex Britton, l. c., pro synon., non Willd.—Ab typo nonnisi differre videtur foliis plerisque angustioribus minus distincte denticulatis, petiolis saepissime satis brevibus vix ultra 1 cm. longis apice haud vel valde indistincte glandulosis, amentis fere semper primo vere in axillis foliorum persistentium apparentibus vel (foliis adultis delapsis) praecocibus vel coetaneis masculis brevioribus vix ultra 3 cm. longis et fructiferis vix ultra 2.5:1–2.2 cm. magnis, glandula dorsali florum femineorum interdum minima.

TYPE LOCALITY.—Southern Arizona: Pima County, Santa Catalina Mountains, Sabino Canyon.

RANGE.—Southeastern Arizona, northern Sonora and Chihuahua (? southwestern New Mexico and Lower California).

SPECIMENS EXAMINED.—Arizona: Pima County, Santa Catalina Mountains, Sabino Canyon, February 20, July 23, 1894, *J. W. Toumey* (f., fr., paratype; N.); also April 8, October 7, 1894, *J. W. Toumey* (st.); also February 15, March 12, April 8, 1894, *J. W. Toumey* (m., f., fr.; "tree 25–50 ft., deeply furrowed bark"); same place, April 10, 1901, *C. L. Shear* (no. 4201, m., fr.; type; N.); same place, alt. 800 m., August 24, 1903, *Thornber* (no. 169a, f.; M.; a forma typica *S. Bonplandianae* vix distinguenda); same place, March 30, 1901, *D. Griffith* (no. 2577, m.; N.).—Mexico: State of Sonora, Guadalupe Canyon, August 28, 1893, *E. C. Merton* (no. 2071, st.; W.; forma aliquid incerta).—State of Chihuahua, Cajou Bonita Creek, July 24, 1892, *E. A. Mearns* (no. 553, st.; W.; "a tree 80 cm. in circumference and 10 m. high"; forma porro observanda).—Lower California, without exact locality, March–June 1897, *A. W. Anthony* (fr., W.; forma aliquid incerta).

I am not sure whether this variety can be regarded as more than a mere form of *S. Bonplandiana*, but judging by the rather insufficient material before me I think it best to keep it as a variety, to which probably the specimen from southwestern New Mexico, enumerated under the type, should be referred. There is a specimen collected by *E. Palmer* in the state of Durango, at Tepehuanes, March 25–April 16, 1906 (no. 9, m.; M., W.) which looks like a pubescent form of var. *Toumeyi* corresponding with the var. *pallida* of the type.

7. S. LAEVIGATA Bebb in Amer. Nat. **8**:202. 1874; in Watson, Bot. Calif. **2**:83. 1879; Ball in Trans. Acad. Sci. St. Louis **9**:69. 1899.

I mention this willow only because its occurrence might be expected in northern Lower California, but I have not yet met with a specimen of it from this region. As I have explained, the Guatemalan willow referred by BEBB to *S. laevigata* belongs to *S. Bonplandiana*. *S. laevigata* is the western counterpart of the eastern *S. longipes*.

8. S. LONGIPES Shuttleworth apud And. in Öfv. K. Vet.-Akad. Förh. **15**:114 (Bidr. Känned. Am. Pilarter). 1858; in Proc. Amer. Acad. **4**:53 (Sal. Bor. Am. 7). 1858; in Walp., Ann. Bot. **5**:744. 1858.—*S. occidentalis* Bosc apud Koch, De Sal. Eur. Com. 16. 1828, non Walter 1788; And. in K. Sv. Vet.-Akad. Handl. **6**:23, *pl. 2, fig. 16* (Mon. Salic.). 1867; in DC. Prodr. **16**^{2}:202. 1868; Bebb in Gard. and For. **8**:364. 1895, in adnot.; Sargent, Silva N.Am. **9**:109, *pl. 465*. 1896, excl. var. pro parte; *S. subvillosa* Elliott ex Nuttall, N.Am. Silva **1**:79. 1843, nom. nud.; *S. longipes*, var. *pubescens* And. in Öfv., l. c. 114; in Proc., l. c. 53; in Walp., l. c. 744; *S. gongylocarpa* Shuttlew. apud And., l. c., pro synon.; *S. floridana* Chapman, Fl. S. U.S. 430. 1860; *S. Humboldtiana* Grisebach, Cat. Pl. Cub. 41. 1866, non Willd.; *S. nigra* ****S. longipes* And. in K. Sv., l. c. 22; excl. var. *venulosa; S. nigra* γ *longipes* And. in DC., l. c. 201. excl. *f. venulosa; S. Bonplandiana* Sauvalle, Fl. Cuba 134. 1873, non Kunth; De la Maza and Roig, Fl. Cuba 64. 1914; *S. occidentalis*, var. *longipes* Bebb in Gard. and For. **8**:363. 1895; *S. amphibia* Small, Fl. Miami 61. 1913.

TYPE LOCALITY (of *S. occidentalis* Bosc).—"In insula Cuba" (coll. *Sieber*, ex Koch).

RANGE.—The typical form, to which the synonymy given above applies, is found from Cuba to northern Florida (Duval and Wakulla counties).

SPECIMENS EXAMINED (from Cuba).—Prov. Pinar del Rio, Galafre, March 7, 1911, *N. L. Britton* and *J. F. Cowell* (no. 9839, m., st.; N., W.);

Pinar del Rio, 1911, *J. F. Cowell* (st.).—Prov. La Habana, San Antonio de los Baños, December 18, 1905, *Van Hermann* (no. 3332, fr.); Playa de Mariano, February 22, 1910, *N. L. Britton* and *P. Wilson* (no. 4521, f.; G., N., W.); Batabano, wet coastal Savanna, April 12, 1912, *N. L. Britton, J. F. Cowell,* and *C. de la Torre* (no. 13359, st.; N., W.).—Prov. Santa Clara, Cienaga de Zapata, March 26 [1860–64], *C. Wright* (no. 2132, m., st.; G., M., W.).—Prov. Camaguey "ad las Piedras," February 1824, *Poeppig* (f.; M.).

This species, which is well represented in the southeastern and central United States by var. **Wardii** (Bebb) Schn., nov. comb., and by var. *venulosa* (And.) Schn., is said by ANDERSSON to occur also in Trinida[d]. Beyond the borders of the United States I have only seen the specimens cited from Cuba. It seems to be entirely absent from Mexico, and I shall deal with this difficult and variable species in my final book.

Sect. IV. LONGIFOLIAE And. in Öfv. K. Vet. Ak.-Förh. **15**:116. 1858; in Proc. Amer. Acad. **4**:55 (Salic. Bor. Am. 10). 1858; in Walp., Ann. Bot. **5**:745. 1858; in K. Sv. Vet.-Akad. Handl. **6**:54 (Mon. Salic.). 1867; in DC. Prodr. **16**^{2}:214. 1868; Bebb in BOT. GAZ. **16**:103. 1891; Rowlee in Bull. Torr. Bot. Club **27**:247. 1900; Schneider, Ill. Handb. Laubh. **1**:32. 1904; Ball in Coult. and Nels., New Man. Rocky Mt. Bot. 130. 1909.

This is a well marked and entirely American section. There are no other willows closely related to those of this section, either in America or in the Old World. Probably the species of the sect. ALBAE Borr. (not of sect. FRAGILES Koch) may represent the nearest relatives to the LONGIFOLIAE. In Mexico there is only one species widely distributed; the other forms of this group mentioned later reach our territory only in its most northern parts. It may be mentioned that, according to GÄRTNER (Vergl. Blattanatomie Gatt. *Salix*, Diss. Göttingen, 1907, p. 54) *S. macrolepis* Turcz. from Northeastern Asia shows "eine so ausgesprochene Aehnlichkeit im Blattbau, dass es keinen Augenblick zweifelhaft sein kann, dass die nächsten Verwandten von *S. macrolepis* Arten wie *S. Hindsiana* und *S. longifolia* sind." I have dealt with this interesting Asiatic species in Sargent, Pl. Wilson. **3**:102. 1916, but I have seen only a poor specimen. Even if GÄRTNER has examined material of the true *macrolepis*, I am not convinced that similar anatomical characters can be taken for a proof of close taxonomic relationship in a case where the morphological characters of the flowers are, apparently, so different.

9. S. TAXIFOLIA Kunth in Humb. and Bonpl., Nov. Gen. Pl. **2**:18. 1817; Syn. Pl. Aequinoct. **1**:364. 1822; And. in Öfv., l. c. 117, excl. var. *microphylla;* in Proc., l. c. 56(11); in Walp., l. c. 746; in K. Sv., l. c. 57, pro parte; in DC., l. c. 215, pro parte; Hemsl. in Biol. Centr. Am. Bot. **3**:180. 1883; Brandegee in Zoe **4**:406. 1894; Rowlee in Bull., l. c. 249, *pl. 9, fig. 2;* Jones, Willow Fam. Gr. Plat. 25. 1908; Goldman in Contrib. U.S. Nat. Herb. **16**:321. 1916. ?*S. taxifolia*, b *lejocarpa* And. in K. Sv., l. c. 57; in DC., l. c. 215; ?*S. taxifolia* α *sericocarpa* And., l. c. 57; ?*S. taxifolia* α *sericocoma* And. in DC., l. c. 215.

TYPE LOCALITY.—"Colitur in Hortis Mexici, Queretari, Zelayae, alt. 900–1200 hex."

RANGE.—From Mexico I have seen wild specimens only from the state of Durango and Chihuahua, and also from Lower California. It is also found in southeastern Arizona, southern New Mexico, and southwestern Texas.

SPECIMENS EXAMINED.—Mexico: State of Durango, vicinity of the city of Durango, August 1896, *E. Palmer* (no. 473, m.; the specimen in the Gray Herbarium consists of two forms, the leaves of the left one being rather short and broad).—State of Chihuahua, valley near Chihuahua, October 5, 1885, *C. G. Pringle* (no. 23½, m., f., fr.); same place, April 6, 1886, *C. G. Pringle* (no. 864, m.; W.); near Balleza, September 23, 1898, *E. H. Goldman* (m.; G.); Cajou Creek, near the U.S. Boundary line, July 2, 1892, *E. A. Mearns* (no. 398, st.; N., W.); San Pedro River, October 12, 1892, *E. A. Mearns* (no. 1111, m.; N.).—Lower California, Santa Anita (Cape Region), March 1901, *C. A. Purpus* (no. 232, m.; W.; forma satis latifolia); from San Bernardo to El Sauz, Sierra La Laguna, January 21, 1906, *E. W. Nelson* and *E. A. Goldman* (no. 7434, m.; W.); Corral Piedra, September 9, 1893, *J. G. Brandegee* (f.; W.).—Without exact locality, 1846, *T. Hartweg* (no. 391, m.; ex Herb. Hooker in Herb. N.).

I have not yet seen a type specimen of the typical *S. taxifolia* of which HUMBOLDT and BONPLAND apparently collected only specimens of cultivated plants. All the specimens before me from central and southern Mexico belong to var. *microphylla*. The typical form seems to be restricted to the central and western part of northern Mexico, where it occurs probably, also in Sonora, and to the parts of the southern central United States mentioned.

There are the following specimens from Chihuahua which come very near typical *S. taxifolia*, but in some respects resemble *S. exigua* (var. *stenophylla*). They may be regarded as belonging to a separate form of *S. taxifolia* also represented in the United States which I am not yet able to interpret correctly. I hope I can deal with it finally in my future book. Bachimba Canyon, March 23, 1885, *C. G. Pringle* (no. 95; f.; G.); vicinity of Chihuahua, alt. about 1300 m., April 8–27, 1908, *E. Palmer* (no. 39, m.; G., M., W.). Another

specimen collected by *Wilkinson*, April 4, 1885 (m.; W.), the exact locality of which I cannot discover, shows rather large elliptic anthers.

The varieties distinguished by ANDERSSON as var. *lejocarpa* and var. *sericocarpa* (*sericocoma*) with glabrescent or densely hairy capsules I cannot identify because he does not cite any specimens. The young ovaries are always pubescent, and even the ripe fruits seem to be never wholly glabrous. See also my remarks under the following variety.

9b. S. TAXIFOLIA, var. **microphylla** Schn., nov. var.—*S. microphylla* Schl. and Cham. in Linnaea **6**:354. 1831; Hooker and Arn., Bot. Beech. Voy. 310. *pl. 70*. 1840; Mart. and Gal. in Bull. Acad. R. Brux. **10**[1]:345 (Enum. Pl. Gal. Mex. 5). 1843; Rowlee in Bull. Torr. Bot. Club **27**:249. 1900, pro parte; *S. taxifolia* And., l. c. and Hemsl., l. c. (sub *taxifolia*) pro parte, non Kunth; Loes. in Bull. Herb. Boiss. **7**:545 (Pl. Seler. 67). 1899.—A typo praecipue recedit: pubescentia ramulorum novellorum magis villosa vel fere subhirsuta, foliis ut videtur minus crassis subtus magis discoloribus distinctius sericeis interdum oblanceolatis et pro longitudine satis latis distinctius denticulatis, stipulis ovato-lanceolatis vel lanceolatis petiolo brevissimo sublongioribus, floribus masculis fere semper glandula tantum ventrali praeditis, amentis fructiferis subcrassioribus 2:1.2 cm. magnis.

TYPE LOCALITY.—Mexico, state of Vera Cruz, "ad ripam arenosam fluminis Tecolutensis prope San Pablo."

RANGE.—Central Mexico to Guatemala and Porto Rico. I have seen specimens from the states of Vera Cruz, San Luis Potosi, Coahuila, Terr. Tepic, Jalisco, Michoacan, Morelos, Puebla, Oaxaca, and from Guatemala and Porto Rico.

SPECIMENS EXAMINED.—The numerous Mexican specimens I have seen will be enumerated in my final book. Guatemala: on the river Pinula, on the road from Guatemala to Amatillan, 1845, *Skinner* (f., ex Herb. Bentham in Herb. N.).—Porto Rico: "Lago San José, près San Juan, October 1909," *Hiorámi* (m.; G.; an indigena?).

This variety is undoubtedly very closely related to the typical *taxifolia* and can hardly be regarded as a good species. The principal characters have already been stated. In *S. taxifolia* the leaves are somewhat longer, narrower, and more entire, the stipules are wanting or scarcely developed, the male flowers always possess a dorsal gland, and the fruiting aments are, usually, more slender.

The form regarded by ROWLEE as *S. microphylla* does not in my opinion fully agree with the typical one collected by *Schiede* and *Deppe* of which I have

seen a sterile co-type (Herb. M.). ROWLEE's form is apparently identical with that described and figured by HOOKER and ARNOTT, but the flowers of the only specimen seen by ROWLEE from Colima (leg. *E. Palmer*, no. 1193, January 9 to February 6, 1891; m.; G., W.) possess mostly two glands. It seems to me somewhat intermediate between the typical *taxifolia* and var. *microphylla* s. str. and needs further investigation.

10. S. EXIGUA Nutt., var.—*S. exigua* Goldman in Contrib. U.S. Nat. Herb. **16**:320 (Pl. Low. Cal.). 1916.

S. exigua Nutt. sensu latissimo is a wide spread willow from the Northwest Territories through the western United States (except along the Pacific Coast and the most of California) to Arizona, southern California, and New Mexico. In my opinion this species may be divided into several varieties which of course seem to be connected by intermediate forms. Having not yet finished my study of those forms I am not able to determine the following few specimens from Mexico with certainty. I can only enumerate them and add a few notes.

There is, first, a specimen from Lower California: Arroyo de Leon, northwest slope of the San Pedro Martir Mountains, alt. 950 m., July 4, 1905, *A. E. Goldman* (no. 1200, m.; W.). It can probably be referred to *S. exigua*, var. **stenophylla** (Rydbg.) Schn., nov. var.,[13] but owing to the absence of female flowers I am not sure of its relationship. To the same form seems to belong a male specimen from Chihuahua: along the Rio Grande, near Ciudad Juarez, 1911, *E. Stearns* (mixed in Herb. N. with a fruiting branch of *S. Gooddingii*). *C. G. Pringle's* no. 23 from the same state, Bachimba Canyon, May 30, 1885 (m.; G.), which has been distributed as *S. taxifolia*, probably represents the same form of *exigua* with early flowers which always look rather different from those appearing later in the season on longer, more leafy peduncles. The aments are very short, but the material is too insufficient to say more. At

[13] *S. stenophylla* Rydberg in Bull. Torr. Bot. Club **28**: 272. 1901 has been described from Colorado as "nearest related to *S. exigua* Nutt." It is, in my opinion, not a good species, but probably more than "an inconstant form" (Ball in Coult. and Nels., New Man. Rocky Mt. Bot. 131. 1909), and I am inclined to use this name for what I call the southeastern and southern variety of *exigua*, the typical form of which seems to be confined to Nevada (and some of the adjacent counties of California), eastern Oregon, Idaho, western Montana, eastern Washington and northward; while var. *stenophylla* extends from Wyoming to eastern Nebraska (in probably a little different form), Colorado, New Mexico, Arizona, and probably northern Chihuahua. The forms from southern California and northern Lower California may be more closely related to typical *exigua*. The var. *stenophylla* differs chiefly in having folia saepe distinctius denticulata (interdum fere ut in *S. longifolia*), ovaria (vel saltem fructus) longius pedicellata pedicello glandulam saepissime 2plo superante, glabriuscula vel ab initio glabra. The oldest name for this form may be *S. Hindsiana*, var. *tenuifolia* And., Mon. p. 56, of which I have not yet seen the type (*Burke*, Snake River).

first sight *C. G. Pringle's* no. 220 from Ciudad Juarez (the former Paso del Norte), May 4, 1885 (m., f.; N.), looks very similar to *S. exigua*, var. *stenophylla*, but the stigmas are rather long and slender. This form needs special observation.

Somewhat more different are specimens from Lower California: near the Tia Juana, April 6, 1882, *M. E. Jones* (no. 3730, m., f.; N., W.), the female flowers of which have rather long stigmas more or less intermediate between those of the flowers of *S. exigua* and *S. sessilifolia* Nutt. The ovaries are glabrous and have a pedicel of about the same length as the gland. There are a few old leaves (apparently of the previous season) which closely resemble those of *S. sessilifolia*, var. **leucodendroides** (Rowlee) Schn., nov. comb. (*S. macrostachya*, var. *leucodendroides* Rowlee in Bull. Torr. Bot. Club **27**:250. *pl. 9. fig. 6.* 1900), the most southern form of *sessilifolia* Nutt. sensu lato. There may be hybrids between this variety and *exigua* in southern California and in the adjacent parts of Lower California where var. *leucodendroides* is likely also to occur. JONES'S specimens represent the early flowering form with rather shortly peduncled aments. "The peculiar swelling just below the stigma," which, according to RYDBERG, is a main feature of his *S. stenophylla*, may be observed in almost every form of *exigua*, *longifolia*, or other species of this section. The form collected by *Jones* may be identical with that of *LeRoy Abrams* on the Tia Juana River in San Diego County, California, May 14, 1903 (no. 3485, f., fr.; G.), which I can hardly distinguish from typical *exigua*.

There remains another doubtful form from Chihuahua, Puerta de St. Diego, alt. 1800 m., April 13, 1891, *C. V. Hartman* (no. 625, m.; "8–12 ft. high"), which has been distributed as *S. taxifolia*. It is a very early flowering form with small subsessile ovoid aments (6–12 mm. long) and very narrow short young leaves (up to 12 by 0.5 mm.). According to the globular anthers it may be an unusually early flowering *taxifolia;* on the other hand one might regard it as an abnormal state of *exigua stenophylla*.

11. S. LONGIFOLIA, var. ANGUSTISSIMA And. in Öfv. K. Vet.-Ak. Förh. **15**:116. 1858, excl. specim. Wrightii no. 1875; in Proc. Amer. Akad. **4**:56 (Sal. Bor. Am. 10). 1858; in Walp., Ann. Bot. **5**:746. 1858.—*S. longifolia* *** *opaca* And. in K. Sv. Vet.-Akad. Handl. **6**:55 (Mon. Salic.). 1867, quoad specim. Berlandierii no. 2341; *S. longifolia* γ *argyrophylla* And. in D.C Prodr. **16**^{2}:214. 1868, quoad specim. Berlandierii no. 2341 (sphalm. 2371); Coulter in Contrib. U.S. Nat. Herb. **2**:419 (Man. Phan. W. Texas). 1894, prob. pro parte maxima; *S. Thurberi* Rowlee in Bull. Torr. Bot. Club **27**:252. 1900; Blankinship in Rep. Mo. Bot. Gard. **18**:194. 1907.

TYPE LOCALITY.—Probably Texas, exact locality unknown to me (coll. *Berlandier*).

RANGE.—Central Texas to New Mexico (Dona Ana County) and northeastern Mexico (Coahuila and Nuevo Leon).

SPECIMENS EXAMINED (from Mexico).—State of Coahuila: Jimulco, by streams, alt. 1300 m., October 10, 1905, *C. G. Pringle* (no. 10086, m.; N., W.; "a medium sized tree").—State of Nuevo Leon: Monterey, along the stream through city, May 1891, *C. K. Dodge* (no. 132, m.; M., W.; looks somewhat like var. *angustissima*×*S. taxifolia*).

This willow seems to me very closely related to *longifolia* and apparently connected with it by intermediate forms. I do not regard it as a distinct species, but I cannot agree with WOOTON and STANDLEY, in Contrib. U.S. Nat. Herb. **19**: 160 (Fl. N.Mex.). 1915, that "*S. Thurberi* Rowlee is a form [of *exigua*] with longer leaves that are noticeably dentate," and that "it is not essentially different from *S. exigua*" as understood by these authors. The main difference of var. *angustissima* from typical *longifolia* is the absence of a dorsal gland in the male flowers and the dense silvery silky (shining) pubescence of the young ovaries. The leaves of the fertile branchlets are up to 4–8 cm. long and 1.5–5 mm. wide. The dentation and nervation are those of typical *longifolia*.

ROWLEE made a mistake in attributing all his specimens of *Thurbeir* (nos. 2368, 95, and 2341 in the Gray Herb.) to *G. Thurber*. Only no. 95 was collected by *Thurber*, while nos. 2341, 2368 are numbers of *Berlandier* and have been cited by ANDERSSON with nos. 911 and 3019 as the co-types of his var. *angustissima*, a fact not mentioned at all by ROWLEE.

There is a sterile specimen from the state of Durango, alluvial valley of Rio Nazas, April 14, 1847, *J. Gregg* (no. 442; M.), which may belong to our variety. The young leaves measure up to 7 cm. in length and 6 mm. in width.

There remains another specimen of a willow of this section from Lower California, ?Causito, May 20, 1883, *C. R. Orcutt* (no. 1180, fr.; M.; distributed as *longifolia*), which possibly represents the form called *S. Parishiana* by ROWLEE in Bull. l. c. 249. Unfortunately I have not yet had the opportunity to examine the types of ROWLEE's species, collected by *F. W. Hobby* in southern California, San Bernardino County, Matilija Canyon (nos. 54, 55). As far as I can judge by the somewhat inexact description and by the material I have seen from southern California, *S. Parishiana* might be regarded as a species intermediate between *exigua* and *sessilifolia leucodendroides*, differing from the latter in the narrower, more glabrescent leaves and the shorter and slenderer fruiting aments, and from the former in the longer, narrower, more linear lobes of the stigma mostly borne by a short style. *Orcutt's* specimen has short old fruiting aments measuring not over 2 cm. in length and 8 mm. in thickness. According to ROWLEE's statement in his description, the aments are "2–3 cm. long by 1–2 cm.," but in the key he says "aments medium size, 3 cm. or more in length."

first sight *C. G. Pringle's* no. 220 from Ciudad Juarez (the former Paso del Norte), May 4, 1885 (m., f.; N.), looks very similar to *S. exigua*, var. *stenophylla*, but the stigmas are rather long and slender. This form needs special observation.

Somewhat more different are specimens from Lower California: near the Tia Juana, April 6, 1882, *M. E. Jones* (no. 3730, m., f.; N., W.), the female flowers of which have rather long stigmas more or less intermediate between those of the flowers of *S. exigua* and *S. sessilifolia* Nutt. The ovaries are glabrous and have a pedicel of about the same length as the gland. There are a few old leaves (apparently of the previous season) which closely resemble those of *S. sessilifolia*, var. **leucodendroides** (Rowlee) Schn., nov. comb. (*S. macrostachya*, var. *leucodendroides* Rowlee in Bull. Torr. Bot. Club **27**:250. *pl. 9. fig. 6.* 1900), the most southern form of *sessilifolia* Nutt. sensu lato. There may be hybrids between this variety and *exigua* in southern California and in the adjacent parts of Lower California where var. *leucodendroides* is likely also to occur. JONES's specimens represent the early flowering form with rather shortly peduncled aments. "The peculiar swelling just below the stigma," which, according to RYDBERG, is a main feature of his *S. stenophylla*, may be observed in almost every form of *exigua*, *longifolia*, or other species of this section. The form collected by *Jones* may be identical with that of *LeRoy Abrams* on the Tia Juana River in San Diego County, California, May 14, 1903 (no. 3485, f., fr.; G.), which I can hardly distinguish from typical *exigua*.

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Sect. V. SALICES DIANDRAE, excl. LONGIFOLIAE.[14]

12. S. HARTWEGII Bentham, Pl. Hartw. 52. 1840; Hemsl. in Biol. Centr. Am. Bot. **3**:180. 1883.—*S. humilis* **S. Hartwegii* And. in K. Sv. Vet.-Akad. Handl. **6**:112, *pl. 6, fig. 62** (Mon. Salic.). 1867; *S. humilis* δ *?Hartwegii* And. in DC. Prodr. **16**^{2}:236. 1868.—Ad descriptionem brevem auctoris addenda et emendanda: habitus ?, ramuli hornotini (autumno floriferi) pl. m. dense griseo- vel flavescenti-tomentelli, angulati, versus basim et annotini purpureo-fusci glabriusculi, vetustiores ut videtur glabri, lenticellis late ellipticis flavis paucis conspersi. Gemmae foliiferae ovatae sed rostratae, ventre subapplanatae, lateraliter leviter carinatae, glabrae vel apice sparse pilosae, ad 8 mm. longae. Folia elongato-lanceolata vel anguste elliptico-lanceolata, basi acuta vel subobtusa, satis subito in petiolum contracta, apice acuta vel brevissime tenuiter acuminata, 3.5:0.7 ad 9.5:1.6 cm. magna, superne intense viridia, ut videtur nitidula, initio etiam in facie sparse (an densius ?) pilosa, dein tantum ad costam subprominentem (et partim ad nervos laterales) tomentella, subtus discoloria, glaucescentia vel cinerascentia, pruinosa, initio pl. m. dense dein tantum ad nervos prominulos axillasque subbrunnescenti- vel griseo-villosulo-tomentella, costa elevata glabrescente, margine breviter et versus apicem distinctius glanduloso-denticulata. Petioli 2–8 mm. longi, superne sulcati, basi dilatati, undique tomentelli. Stipulae in ramis novellis satis distinctae, semicordatae, acutae, ad 7 mm. longae, glanduloso-denticulatae, ut folia pilosae. Amenta autumno in axillis foliorum adultorum apparentia, sessilia, brevia, densiflora, rhachi villosa, basi perula gemmarum suffulta; mascula ad 1.8:0.7 cm. magna; bracteae oblongae, apice truncatae, brunnescentes, praesertim ad basim utrinque longe pilosae; stamina 2, filamentis glabris liberis dein bracteas duplo superantibus; glandulae duae, ventralis ovato-rectangularis, quam bractea 3–3½plo brevior, dorsalis minor; amenta feminea ad 2:1 cm. magna, ut videtur recurvata; ovaria ovato-lanceolata, in stylum distinctum iis circ. 4–5plo breviorem

[14] I do not refer the following species to distinct sections because I do not yet know how to limit those sections to which these Mexican species belong. Some of them are very little known, and it needs further investigation to decide the question whether or not the species nos. 11–13 may form a special section on account of the dorsal gland present in the male flowers.

attenuata, pedicellis dimidio ovarii sublongioribus suffulta, glabra, stigmatibus linearibus bifidis stylo subaequilongis coronata; glandula 1, ovato-rectangularis, obtusa, pedicello 2–3plo brevior; bracteae oblongae, obtusae, ut in floribus masculis pilosae, pedicellum subsuperantes; fructus e basi subacuta ovoideo-lanceolati, subrostrati, circ. 4 mm. longi, pedicello 1.5–2 mm. longo excluso.

TYPE LOCALITY.—Mexico: State of Michoacan, prope Aganguio.

RANGE.—Central Mexico: States of Michoacan and Mexico.

SPECIMENS EXAMINED.—Mexico: State of Michoacan, "prope Aganguio," 1840, *Th. Hartweg* (no. 390, m.; co-type in Herb. N.).—State of Mexico, north slope of Volc. Toluca, September 9, 1893, *E. W. Nelson* (no. 26, f., fr.; W.).

This species seems most closely related to *S. mexicana* Seem., both possessing a dorsal gland in the male flowers. The late time of flowering cannot be regarded as a valuable taxonomic character because there are spring flowering forms of *S. mexicana*, and of *S. lasiolepis* I have seen forms of southern California flowering in the fall. The relationship of *S. Hartwegii* and the following species to *S. lasiolepis* and other species of sect. CORDATAE needs further investigation.

13. S. MEXICANA v. Seemen in Bot. Jahrb. **21**, Beibl. 52:9. 1895.

TYPE LOCALITY.—Mexico: State of Hidalgo, Zacualtipan[15] (coll. *Berlandier*, ex Seemen).

RANGE.—Central Mexico: States of Hidalgo, Mexico, Pueblo.

SPECIMENS EXAMINED.—Mexico: State of Hidalgo, Sierra de Pachuca, by brooks, alt. 2900 m., September 8, 1899, *C. G. Pringle* (no. 8237, f., m., st.; "10 to 15 ft."); same locality, alt. 2800 m., September 1, 1906, *C. G. Pringle* (no. 13783, m., f.; G., W.); Tulancingo, August 26, 1893, *E. W. Nelson* (m.; W.).—State of Puebla, Barranca below Honey Station, alt. 1680 m., September 9, 1906, *C. G. Pringle* (no. 13817, st.; G.).—State of Mexico, Ixtaccihuatl, along brooks, March 1906, *C. A. Purpus* (no. 1801, f., st.; G., M., W.).

The specimens before me agree well with v. SEEMEN's description, and the Sierra de Pachuca is not far from the type locality. SEEMEN himself states that his species is closely related to *S. Hartwegii* (see above); especially by the presence of a dorsal gland which, however, is not mentioned by SEEMEN. It may easily be distinguished from *S. Hartwegii* by its glabrous branchlets and leaves, but the ovaries are glabrous in both the species, not hairy in *S. Hartwegii*, as SEEMEN states. The male specimen of *Nelson* shows a few remaining

[15] SEEMEN cites also "St. Pietro et St. Paulo (*Ehrenberg*, *Uhde*)." There are many localities of this name in Mexico, and not having seen the specimens I am not sure about the exact place where they were found.

hairs near the buds on the branchlets, a more distinct grayish silky pubescence of the bracts, and a very small dorsal gland.

14. **S. Schaffnerii** Schn., spec. nov.—Habitus (?), ramuli hornotini dense griseo-villoso-tomentelli, pl. m. angulati, obscure flavescentes, annotini fuscescentes, paullo glabrescentes, vetustiores purpureo-fusci, ut videtur haud omnino glabrescentes. Gemmae foliiferae ovato-oblongae, adpressae, ventre applanatae, acutae, pl. m. villoso-tomentellae, subfuscae, ad 6 mm. longae, floriferae crassiores obtusioresque. Folio adulta subcoriacea, satis crassa, inferiora minora elliptico-oblonga, superiora longiora elliptico-lanceolata, basi acuta vel obtusiora, satis subito in petiolum contracta, apice breviter acuta, inferiora obtusiora 3:1.4 ad 6:1.5–1.8 cm., superiora 6:1 ad 8:1.8 vel 9.5:1.3 cm. magna, superne ut videtur obscure viridia, novella satis villoso-tomentella, dein costa vix prominula nervisque lateralibus planis exceptis subglabrescentia, subtus pruinosa, tomento densi griseo-flavescenti obtecta, costa nervisque lateralibus prominentibus in foliis adultis interdum partim glabrescentibus flavescentibus, rete nervillarum satis distincte subprominente, margine pl. m. distincte et satis irregulariter subcrenato-denticulata. Petioli 5–10 mm. longi, superne basi dilatata excepta convexi vel plani, omnino tomentelli. Stipulae minimae, deciduae, semi-ovato-lanceolatae, acutae, dense pilosae. Amenta tantum feminea visa, (ut videtur in autumno) in axillis foliorum adultorum apparentia, sessilia, basi perula gemmarum dein decidua suffulta, elliptico-oblonga, florifera ad 1.5 cm. longa et 0.8 cm. crassa (frucifera majora?), densiflora, rhachi villosa; ovaria ovato-lanceolata, glabra vel sparse pilosa, in stylum distinctum apice breviter bifidum medio ovarii aequilongum producta, pedicello distincto ovario subaequilongo glabro vel sparse piloso suffulta, stigmatibus minimis stylo sub 4plo brevioribus breviter emarginatis; bracteae obovato-oblongae, discolores, apice rotundatae, utrinque (saltem extus) pilis longis bracteam ½plo superantibus praeditae; glandula 1, satis parva, ovato-oblonga, apice satis obtusa, pedicello 5–6plo brevior.

TYPE LOCALITY.—Mexico: "in convalli San Luis Potoşi."

RANGE.—Central Mexico: State of San Luis Potosi, probably also in Vera Cruz.

SPECIMENS EXAMINED.—Mexico: State of San Luis Potosi, "ex convalli S.L.P.," 1877, *J. G. Schaffner* (no. 265, f., type; N.).—State of Vera Cruz, "in montibus San Miguelito,"[16] 1876, *J. G. Schaffner* (no. 894, f.; G.).

From *S. Hartwegii* this species is easily distinguished by the characters given in the key. Unfortunately, I have seen only female specimens, according to which it seems to be most closely related to *S. lasiolepis*, of which I have seen a form of southern California with half-evergreen leaves, the aments appearing in the axils of the remaining leaves. But this species differs in the almost glabrous or much less pubescent leaves, in the longer cylindrical flowering aments, and in the longer gland which is two-fifths to one-half as long as the pedicel.

15. S. LASIOLEPIS Benth., Pl. Hartweg. 335. 1857.

TYPE LOCALITY.—California: "ad ripas fluviorum Salinas et Carmel prope Monterey" (coll. *Hartweg*, no. 1955).

RANGE (in Mexico).—States of Coahuila, Chihuahua, Lower California.

SPECIMENS EXAMINED.—Lower California: Nachoguero Valley, June 4, 1894, *L. Schoenfeldt* (no. 3426, fr.; W.); La Laguna, Sierra La Laguna, alt. 1650 m., January 27, 1906, *E. W. Nelson* and *E. A. Goldman* (no. 7462, m.; W.).—State of Chihuahua: Valley near Chihuahua, March 3, October 4, 1866, *C. G. Pringle* (no. 709, m., fr., st.; distributed as *S. irrorata* And.).—State of Coahuila, mountains near Saltillo, San Lorenzo Canyon, by brooks, alt. 2100 m., April 12, 1906, *C. G. Pringle* (no. 10210, fr., st.; G., M., W.; distributed as *S. Hartwegii* Benth.).

I refer these specimens to *S. lasiolepis* mostly on the authority of C. R. BALL, who determined the sheets of the Washington Herbarium. He has already made an extensive study of the species and forms of the sect. CORDATAE.

16. **S. Rowleei** Schn., nov. spec.—*S. cana* Rowlee in BOT. GAZ. **27**:137. 1899, ut videtur pro parte, non Mart. and Gal.—Planta feminea (no. 13204 Pringlei, no. 680 Greggii): Frutex altus vel arbor ad 6 m. alta; ramuli novelli dense incano-villosuli, annotini floriferi nigro-fusci, paullo glabriores (tomento cano partim obtecti), subangulati, vetustiores pl. m. glabrescentes. Gemmae ut videtur ovato-oblongae, obtusae, tomentellae, bene evolutae

[16] There are two places of this name in Mexico according to Rand McNally's map, one in Jalisco, the other and apparently more prominent in Vera Cruz, about 55 km. west of the peak of Orizaba. HEMSLEY in Biol. Centr. Am. Bot. IV:134. 1887, states that "Wilhelm" Schaffner has sent plants to Dr. Gray "from the neighbourhood of San Luis Potosi" and that he collected also at Orizaba but not in Jalisco. This "Wilhelm" Schaffner is undoubtedly the same as "Dr. J. G. Schaffner" as printed on the labels before me.

ignotae. Folio (matura ignota) elliptica, vel minora ovalia et maxima elliptico-lanceolata, apice acuta, basi acuta vel obtuse cuneata, majora 4:2 ad 7.5:3 cm. magna, superne tantum valde initio subfloccoso-villosa, cito costa nervisque lateralibus (in parte versus costam) subtomentellis exceptis glabrescentia, viridia, subtus initio distinctius subflavescenti-villosa, cito glabrescentia, valde discoloria, albo-coerulea, pruinosa, costa flava pl. m. nervis nervillisque prominulis fere omnino glabris, margine integerrima vel distanter indistincte glanduloso-denticulata. Petioli cano-villosuli, 2–8 mm. longi. Stipulae visae minimae, semiovatae, denticulatae, vix 2 mm. longae. Amenta juvenilia (no. 680 Greggii) circ. ad 3:1 cm. magna, coetanea, pedunculo foliola 3–5 parva ceterum normalia gerente ad 1 cm. longo suffulta, fructifera (no. 13204 Pringlei) 5–8(–9) cm. longa (pedunculo excluso) et ad 1.5 cm. crassa, rhachi villosa. Ovaria ovoideo-conica, pedicello iis duplo breviore incluso glabra, stylo brevi sed distincto apice paullo bifido stigmatibus oblongis bifidis sublongiore coronata; bracteae oblongae, obtusiusculae, pedicellum circ. $\frac{1}{4}$ superantes, brunnescentes, utrinque satis laxe sericeo-lanatae; glandula 1, pedicello triplo brevior, rectangularis, apice truncata vel subbifida; fructus rostrati, pedicello 4plo breviore incluso ad 8 mm. longi, valvis apertis recurvatis.—Planta mascula (no. 8047 Pringlei): ramuli et folia juvenilia (semievoluta) ab iis plantae femineae vix diversa sed folia distinctius glaucescentia. Gemmae in ramulo sterili in herbario Grayi addito ovato-oblongae, ventre applanatae, apice subrostratae, dense subflavescenti-villosulo-tomentellae, subadpressae, ad 12 mm. longae. Amenta pl. m. praecocia, subsessilia, ad 4.5:1.5 cm. magna, pedunculo ad 8 mm. longo foliola parva minima ex parte squamiformia ut cetera pilosa et colorata gerente suffulta, densiflora, rhachi villosa; bracteae oblongo-lanceolateae, apice obtusae vel subacutae, brunnescentes, utrinque laxe longe sericeo-lanatae, circ. 3 mm. longae; stamina 2, filamentis liberis glabris bracteis duplo longioribus, antheris flavis ovali-ellipticis circ. 1.5 mm. longis; glandula 1, ovato-rectangularis, apice truncata, bractea circ. 3plo brevior.—Folia adulta in herb. Grayi ad no. 8047 addita elliptica vel subovato-elliptica, apice acuta, basi subrotundata, ad 11.5:4 cm. magna, superne laete flavo-viridia,

fere omnino glabra, subtus glaucescentia, pruinosa, glabra sed ad costam nervosque elevatos partim ferrugineo-pilosa, rete nervillarum perspicue elevato, textura papyracea; petioli villosuli 7–10 mm. longi.

TYPE LOCALITY.—Mexico: Federal District, Eslava and mountains west of the City of Mexico (female) and Serrania de Ajusco (male).

RANGE.—As above.

SPECIMENS EXAMINED.—Mexico: Federal District, Eslava, thickets, alt. 2300 m., April 14, 1904, *C. G. Pringle* (no. 13204, f. type; W.; "15–20 ft."); mountain border west of the City of Mexico, April 26, 1849, *J. Gregg* (no. 680, f.; M.; "10 ft. high."); Serrania de Ajusco, alt. 2700 m., February 18, 1899, *C. G. Pringle* (no. 8047, m., paratype; G., M., W.; in Herb. N. mixed with fruiting *S. paradoxa;* in Herb. A. mixed with female var. *? cana* and a sterile branch which may belong to the male plant).

I am not fully convinced that the female and male plants really belong to the same species. The male plant may be the same as the female form called by me var. *? cana* below. Certainly, ROWLEE's *S. cana* is not identical with the species of MARTENS and GALEOTTI. The description of these authors is rather incomplete, owing to the lack of fertile material, and I have not seen the type specimen. The statement "folia pollicaria," however, which probably refers to adult leaves, excludes a form like *S. Rowleei*, of which the leaves are much larger. Besides this the type of *S. cana* M. and G. has not been collected "in the same region" as the plant before us, the Peak of Orizaba being about 185 km. distant, as the crow flies, from the Cima de Ajusco. Furthermore, ROWLEE's description does not apply exactly to all the specimens distributed under no. 6794 which ROWLEE cites as his type. The specimens in Herb. A., G., M., and W. consist only of female pieces which rather agree with the author's statement except (the base of the ovaries and) the pedicels being glabrous and not hairy. The male specimens which, I believe, belong to *S. Rowleei* are under *Pringle's* no. 8047 in Herb. G., M., and W.; while in Herb. N. the true male plant is mixed with a fruiting branch of *S. paradoxa* (see later), and in Herb. A. I find on the sheet of no. 8047 a male *S. Rowleei*, a female *S. Rowleei* var. *? cana*, a sterile branch which may belong to *S. Rowleei*, and a branch in winter condition. ROWLEE apparently describes male flowers of *S. paradoxa* or its var. *ajuscana* because he states that the filaments are hairy, while those of no. 8047 before me are glabrous. The male plant of ROWLEE therefore does not belong to *S. Rowleei* m. As to his female plant, there also remains some doubt about its identity, and those forms with a hairy pedicel (and a hairy base of the ovary) may possibly be of hybrid origin and represent a cross between *S. paradoxa*, var. *ajuscana* and typical *S. Rowleei*. After all, this species and the following variety need further observation in the field.

16b. S. ROWLEEI, var. (?) **cana** Schn., nov. var.—*S. cana* Rowlee, l. c., quoad plant. fem. sensu stricto, non Martens and Galeotti.—Habitus ramulique ut in *S. Rowleei* vel *S. paradoxa*. Folia adulta nondum visa, semievoluta textura colore et pubescentia ab iis *S. Rowleei* vix diversa, sed juvenilia magis (ut in *S. paradoxa*) ferrugineo-pubescentia, dein valde glabrescentia. Amenta fructifera ad 7:1.8 cm. magna, pedunculo ad 1 cm. longo foliola pauca parva normalia gerente suffulta, iis *S. Rowleei* satis similia (juvenilia non satis evoluta in ramulo ad no. 8046 in Herb. A. addito ad eandem formam pertinere videntur); flores fructusque iis *S. Rowleei* potius quam iis *S. paradoxae* similia sed pedicello et basi ovarii pilosa diversa.

TYPE LOCALITY.—Mexico: Federal District, La Cima de Ajusco.

RANGE.—As above.

SPECIMENS EXAMINED.—Mexico: Federal District, La Cima de Ajusco, alt. 3100 m., April 16, 1898, *C. G. Pringle* (no. 6794, fr., type; A., G., M.); same locality, alt. 2700 m., February 18, 1899, *C. G. Pringle* (no. 8047 quoad ramul. florif. femin. in Herb. A.).

See the remarks under typical *S. Rowleei* and under *S. paradoxa*.

17. **S. oxylepis** Schn., nom. nov.—*S. latifolia* Mart. and Gal. in Bull. Acad. R. Brux. 10[1]:344 (Enum. Pl. Gal. Mex. 4). 1843, non Forbes 1828; Hemsley in Biol. Centr. Am. Bot. 3:180. 1883.—Habitus?; ramuli novelli annotinique floriferi dense griseo- vel subflavescenti-villosuli vel villoso-tomentelli, subangulati (in no. 230 ramuli floriferi fusci satis glabrescentes), dein cinereo-fusci, glabrescentes. Gemmae bene evolutae non visae, puberulae. Folia tantum juvenilia visa, ovato-elliptica, vel obovato-oblonga, basi cuneata, apice breviter acuta (vel in no. 230 obtusiora), ad 4.5:1.5 cm. magna (in no. 230 ad 3:1.5 cm.), superne viridia, initio pl. m. laxe pubescentia, cito costa villosula excepta glabra, subtus discoloria, initio satis dense griseo- vel fulvo-villosa, dein glabrescentia, glaucescentia, pruinosa, costa nervisque prominentibus flavescentibus, rete nervillarum nondum distincte evoluto, margine subdenticulata (in no. 230 integerrima). Petioli pilosi, ad 4 mm. longi. Stipulae ut videtur minimae, caducae. Amenta subpraecocia vel coetanea, tantum mascula visa, cylindrica, ad 4.5:1.2 cm. magna (antheris delapsis tenuiora), subsessilia vel pedunculo foliola parva

pauca ut normalia villosa gerente ad 1 cm. longo suffulta, rhachi villosa. Bracteae elliptico-lanceolatae, acutae (vel in no. 230 anguste ovato-lanceolatae, subacuminatae), discolores, utrinque longe sericeae, ad 3 mm. longae; stamina 2, filamentis liberis vel ad basim $\frac{1}{6}$ coalitis circ. $\frac{1}{3}$ pilosis dein bracteam circ. $2\frac{1}{2}$plo superantibus valde elongatis, antheris flavis ellipticis; glandula 1, satis crasse et late rectangularis vel late ovato-rectangularis, apice truncata vel subemarginata, bractea circ. 3plo brevior.

TYPE LOCALITY.—Mexico: State of Puebla (or Vera Cruz) "sur les flancs du pic d'Orizaba, à 12000 pieds" [3700 m.] (coll. *Galeotti*, no. 70, ex Mart. and Gal.).

RANGE.—Central Mexico, on and near the Peak of Orizaba.

SPECIMENS EXAMINED.—Mexico: State of Puebla, Mt. Orizaba, alt. 2900–3200 m., March 18, 1894, *E. W. Nelson* (no. 272, m., type of *S. oxylepis* in Herb. W.); Boca del Monte [according to Rand MacNally's map 17 miles east of Esperanza], March 13, 1894, *E. W. Nelson* (no. 230, m.; W.).

S. latifolia Mart. and Gal. is a very little known species, of which the authors give a rather incomplete description of the male plant. Not having seen the type, I am not sure whether these specimens really belong to this species, but regarding the statement "squamis lineari-subulatis elongatis" and the fact that the type had been collected on the same mountain range, I believe that *Nelson's* plant may be identical with that of *Galeotti*. The name *latifolia* has to be changed on account of the earlier *latifolia* Forbes, which is a valid name. Owing to the incomplete material, it is impossible to decide whether *S. oxylepis* is a good species or perhaps only a variety of *S. paradoxa* Kth. s. l., to which those specimens belong that have been distributed as *S. latifolia* by PRINGLE. *Nelson's* specimens were named *S. lasiolepis*, var. *Bigelovi* by BEBB, but so far as I know this variety is entirely absent from Mexico.

18. S. PARADOXA Kunth in Humb. and Bonpl., Nov. Gen. Pl. **2**:20. 1817; Syn. Pl. Aequin. **1**:366. 1822; And. in DC. Prodr. **16**^{2}:226. 1868, in textu sub *S. discolore;* Hemsl. in Biol. Centr. Am. Bot. **3**:180. 1883.—Ad descriptionem auctoris incompletam addenda et emendanda: Arbor humilis densa, ad 6.5 m. alta; ramuli novelli ferrugineo-villosuli, pilis griseis intermixtis, hornotini paullo glabriores, annotini (floriferi) pl. m. tomentelli vel satis glabrescentes, atro-fusci, angulati. Gemmae (in no. 5698) ovato-oblongae, ventre planae, apice subrostratae, subadpressae, brunneae, paullo (saltem ad apicem) pilosae, ad 1 cm. longae. Folia (tantum in no. 5698 submatura) papyracea, oblongo-elliptica vel elliptico-

lanceolata, basi pleraque breviter cuneata, rarius subrotundata, apice acuta, minora inferiora (minimis basi ramulorum exceptis) 5:2 ad 8:2.5 cm. magna, majora superiora ad 13:3.5 cm. (vel ad 10:3.8 cm. in no. 1800 Purpusii) magna, superne tantum novella tomento ferrugineo cito evanescente obtecta, dein costa ferrugineo-tomentosa excepta fere glabra, viridia, subnitidula, nervis lateralibus distincte flavescentibus, etiam rete nervillarum subvisibili, subtus initio densius ferrugineo- vel subgriseo-tomentoso-villosula, cito costa nervisque prominentibus exceptis fere glabra, valde glaucescentia, pruinosa, reticulata, margine integerrima vel saltem versus apicem irregulariter et saepe indistincte glanduloso-subserrata. Petioli 3–13 mm. longi, superne subsulacti, undique ferrugineo-tomentelli. Stipulae cito deciduae, semiovatae vel semilanceolatae, parvae, ad 4 mm. longae, glanduloso-denticulatae, laxe piloase. Amenta praecocia vel subcoetanea, feminea tantum visa, crasse cylindrica, pedunculo brevi ad 1 cm. longo foliola parva lanceolata ut normalia pilosa gerente suffulta, florifera (in no. 1800) ad 6.5 cm. longa et 12 mm. crassa, divaricata, curvata, rhachi villosa; ovaria ovoideo-oblonga, pedicello iis circ. $\frac{2}{3}$ breviore incluso pl. m. dense villosa, stylo pedicello circ. $\frac{1}{3}$ breviore apice bifido coronata, stigmatibus oblongis angustis stylo subaequilongis vel sublongioribus bifidis; bracteae oblongae vel obovato-oblongae, obtusae, discolores, utrinque pl. m. longe albo-sericeo-lanatae, pedicello circ. $\frac{1}{3}$ longiores; glandula 1, ovato-rectangularis, apice truncata, pedicello subduplo vel subtriplo brevior; fructus ovoideo-lanceolati, subrostrati, pedicello circ. $\frac{3}{4}$ breviore incluso 8–9 mm. longi, ut ovaria vel minus dense villosi, valvis apertis satis recurvatis.

TYPE LOCALITY.—Mexico: State of Hidalgo, "prope Moran Mexicanorum, alt. 1330 hex." (coll. *Humboldt* and *Bonpland*, ex Kunth).

RANGE.—Central Mexico: probably from southern Hidalgo through Mexico, Federal District to Oaxaca.

SPECIMENS EXAMINED.—Mexico: State of Mexico, Ixtaccihuatl, alt. 2700–3200 m., December 1905, *C. A. Purpus* (no. 1800, f., fr.; G., M., N.).—Federal district, La Cima de Ajusco, April 18, 1900, *W. Trelease* (no. 135, fr.; M.; according to the large fruiting aments, the distinct styles, and the partly ferrugineous pubescence typical *paradoxa*).—State of Oaxaca, Sierra de San Felice, by springs, alt. 3200 m., May 18, 1906, *C. G. Pringle* (no. 10185, fr.;

"15–20 ft."); same locality, September 26, 1894, *C. G. Pringle* (no. 5698, st.; G.; leaves identical with those of the preceding no. in Herb. M.).

ANDERSSON says that he has seen of *S. paradoxa* nothing but "pauca specimina tantum eaque deformata." His statement "capsulae hirsutae longe pedicellatae, stylo nullo" does not apply to what I take for the typical *paradoxa*. KUNTH does not mention a style; he describes abnormal (androgynous) female aments, and according to his statement "amenta . . . . fructifera subtripollicaria, crassitie polliicis." I regard as *paradoxa* the plant with the very large fruiting catkins. This form has a distinct style which is very short (mostly hidden among the hairs of the apex of the ovary) in var. *ajuscana*, but this variety does not have "folia . . . . subtus nervo et venis primariis prominentibus ferrugineo-tomentosis" as KUNTH says, and the fruiting aments measure only up to 5:1.2 cm.

ROWLEE, in describing *S. Pringlei*, apparently mixed typical forms of *paradoxa* with those of var. *ajuscana*. Furthermore, he seems to have had before him another form with glabrous pedicels (see BOT. GAZ. **27**:137, *fig. 1, a–b*). I have not yet seen a specimen fully agreeing with ROWLEE's description and figure, therefore I regard the true *S. Pringlei* as an obscure form not identical with *Pringle's* no. 6795 of the different herbaria I have seen. *S. Pringlei* may belong to a hybrid between *S. Rowleei* and *S. paradoxa* var. *ajuscana*, which both occur on the Cima de Ajusco.

18b. S. PARADOXA, var. **ajuscana** Schn., var. nov.—*S. Pringlei* Rowlee in BOT. GAZ. **27**:136. 1899, pro parte.—Frutex 0.5 ad 1.5 m. altus; ramuli novelli griseo-villosi, annotini floriferi fusco- vel olivaceo-brunnei, subangulati, parce (vel partim) villosuli vel subglabri, lenticellosi; gemmae bene evolutae nondum visae. Folia tantum semievoluta visa, elliptico-ovalia vel elliptica, apice acuta, interdum subplicata, base acuta vel subobtuse cuneata (vel minora subrotunda), majora 4–6.5:2–2.8 cm. magna (matura probabiliter satis majora), superne initio albo-pubescenti-villosa, dein viridia, costa nervisque lateralibus pl. m. exceptis glabrescentia (saltem in no. 13205), subtus dense albo-pubescenti-tomentosa, costa nervisque flavescentibus prominentibus, rete nervillarum sub pube occulto, glaucescentia, pruinosa, margine integerrima vel ad apicem obscure glanduloso-denticulata. Petioli ad 5 mm. longi, omnino villosuli; stipulae parvae semiovatae, denticulatae, villosulae, ad 3 mm. longae, caducae. Amenta praecocia, subsessilia, basi foliolis parvis squamuliformibus paucis subtus dense sericeis suffulta, rhachi villosa; mascula (in no. 6795) elliptico-cylindrica, ad 4 cm. longa et circ. 12–15 mm. crassa, vix curvata et divaricata; bracteae

discolores, anguste obovato-oblongae, apice rotundatae (interdum leviter eroso-denticulatae), utrinque longe lanato-pilosae; stamina 2, filamentis liberis dein bracteis subduplo longioribus basi $\frac{1}{3}$ villosis, antheris flavis ovoideis; glandula 1, elliptico-rectangularis, bractea 2–$2\frac{1}{2}$plo brevior, interdum satis lata. Amenta feminea florifera cylindrica 3–4:1 cm. magna, fructifera 4–5:1.5–1.7 cm. magna; ovaria ovoideo-oblonga, adultiora circ. 4 mm. longa et pedicello iis subduplo breviore suffulta (in floribus juvenilibus pedicellus quam glandula vix longior); stylus subnullus vel brevis, stigmatibus oblongis bifidis duplo brevior (vel in fructu stigmatibus subaequilingus). Fructus pedicello 3–4plo breviore incluso ad 7 mm. longi, dense villosi.

TYPE LOCALITY.—Central Mexico: Federal district, La Cima de Ajusco.

RANGE.—As above.

SPECIMENS EXAMINED.—Mexico: Federal District, La Cima de Ajusco, alt. 3200 m., April 16, May 21, 1898, *C. G. Pringle* (no. 6795, m., f., fr., type; G., M., W.; "2–5 ft."); same locality, April 16, 1904, *C. G. Pringle* (no. 13205, m., f., st.; G., W.; "2–3 ft."; M.; "dwarf"; forma ut videtur valde ad *S. paradoxam typicam* spectans).

ROWLEE cites *Pringle's* no. 6795 as type of his *S. Pringlei* and says "no staminate plant was collected," but the specimens before me consist of male and female material. Furthermore, ROWLEE states that the pubescence of the leaves is "slightly ferruginous" and that the leaves are "at maturity becoming nearly glabrous." As I have already pointed out, ROWLEE's description does not fit exactly the material distributed under no. 6795, and I think it best not to use the name *Pringlei* for the variety because there may be hybrid forms. ROWLEE apparently overlooked the original description of *paradoxa*. He says that his species "is related to *S. candida*" which, in my opinion, has nothing whatever to do with the Mexican plant.

The var. *ajuscana* differs chiefly from *S. paradoxa* by its almost entirely grayish pubescence, the more elliptic or elliptic-ovate shape of the leaves, the shorter style of the ovaries, and the smaller size of the fruiting aments.

19. S. CANA Martens and Galeotti in Bull. Acad. Roy. Brux. 10[1]:344 (Enum. Pl. Gal. Mex. 4). 1843; Hemsley in Biol. Centr. Am. Bot. III:179. 1883.—Ramuli annotini tomento brevi denso cano vestiti, pl. m. angulati, dein subglabrescentes, atro-brunnei vel atro-purpurei; gemmae bene evolutae non visae. Folia adulta ignota, juvenilia anguste oblanceolata, basi subacuta, apice distinctius acuta et tenuiter mucronulata, 9:2 ad 18:4 mm. magna,

integerrima, superne viridia, ?nitidula, initio laxe sericeo-villosa, dein costa excepta glabrescentia, subtus discoloria, initio distincte partim brunnescenti-sericeo-villosa, dein ut videtur satis glabrescentia (et ? glaucescentia). Petioli brevissimi, ad 2 mm. longi, pilosuli. Stipulae non visae. Amenta mascula coetanea, minima, ovata, densiflora, ad 8:6 mm. magna, basi foliis iis longioribus obsita, rhachi villosula; bracteae obovato-oblongae, brunnescentes, apice rotundatae, utrinque satis laxe crispato-pubescentes; stamina 2, filamentis liberis bracteam ad 2plo superantibus basi $\frac{1}{3}$ villosulis, antheris flavis parvis elliptico-globosis; glandula 1, ovato-rectangularis, apice truncata, circ. $1\frac{1}{4}$ bracteae aequans.

TYPE LOCALITY.—Central Mexico: "habite les ravines humides du pic d'Orizaba, à environ 11 ou 12000 pieds d'élévation absolue" [3400–3700 m.] (coll. *H. Galeotti*, no. 69, ex. Mart. and Gal.).

RANGE.—Uncertain.

SPECIMENS EXAMINED.—Mexico: without exact locality, "Penas carg. April 1839," *C. Ehrenberg* (no. 1280, m.; W., ex Mus. Bot. Berol.).

The description of *cana* by the authors is very short and is based on sterile material only, and I have not yet been able to compare type material. It runs: "Canescenti-glauca; ramulis cinereo-subtomentosis, foliis subsessilibus oblongis integerrimis acutiusculis glabris subtus glaucis.—Amenta ignota, stipulae non visae, folia pollicaria.—Affinis *Salici paradoxa* H.B.K." By ROWLEE *Pringle's* no. 6794 had been regarded as *S. cana* M. and G., but, as I have explained under *S. Rowleii*, the plant from the Cima de Ajusco does not agree with the description of *S. cana*. This species of which the authors had apparently before them adult sterile specimens has "folia pollicaria." Considering the younger state, *Ehrenberg's* plant agrees well with the statements of MARTENS and GALEOTTI. Nevertheless, I am not yet sure about the identity of the two plants, especially as we do not know the exact habitat of *Ehrenberg's* plant. It has been referred to *S. cana* by such an eminent salicologist as V. SEEMEN according to the handwriting on the sheet.

There remains one more species described from Mexico:[17] *S. Endlichii* v. Seemen in Fedde, Rep. Spec. Nov. **5**:19. 1908. The type was collected by *R. Endlich* in the state of Chihuahua, "in

[17] There is also a *S. cinerea* Sesse and Moçino, Fl. Mex. ed. 2. 229. 1894, excl. syn., non L., described as "*Salix* foliis oblongis, denticulatis, subtus villoso-cinereis, stipulis semicordatis. F.M. Habitat in montibus umbrosis S. Angeli et plurimis Hisp. locis." There are 3 different localities bearing the name San Angel in Mexico. The description is much too incomplete to make even a guess at the identity of this obscure species.

den Thälern der westlichen Sierra Madre, 2250–2450 m. hoch," April 16–17, 1906 (no. 1225*a*, 1226). I have not seen any form from this state which agrees with V. SEEMEN's description, and unfortunately I have not been able to compare the type. Judging by the ample description, it seems to me that this species must be very similar to *S. cana* sensu meo. The narrow lanceolate leaves measure up to 1.6 cm. in length and 0.3 cm. in width; the aments are described as "coetanea, sessilia, basi foliis parvis obsita, parva, subglobosa, usque 0.7 cm. longa et lata"; and the fruits are "stipata (stipite capsulae dimidium aequante, dense incano-pubescente), e basi ovali conica, dense incano-pubescentia, stylus brevissimus, stigmata brevia emarginata capitellata; glandula 1 posterior, ovalis, truncata, capsulae stipitis dimidium aequans." After all, *S. Endlichii* may be a rather glabrescent form of *S. cana* or a closely allied species.

There are several Mexican specimens left which I believe may be regarded as of hybrid origin, or partly even as new species. At the present time I can only enumerate them, adding a few remarks. We need a much better understanding of the Mexican willows and more copious material of the forms in question before we can obtain a correct opinion of them.

(?) 1b×6. S. HUMBOLDTIANA, var. STIPULACEA×S. BONPLANDIANA.—State of Oaxaca, valle de Etla, alt. 1580 m., April 1906, *C. Conzatti* (no. 1722, fr.; W.).

It differs from the first in the smaller, more narrowly lanceolate subconcolorous leaves, which measure up to 10 by 1.2 cm. and possess numerous stomata in the upper epidermis. The branchlets are finely puberulent and dull reddish brown; the dense curved fruiting aments borne on short leafy peduncles (1 cm.) measure about 4 by 1 cm. The influence of *S. Bonplandiana* may be seen in the comparatively broader and firmer leaves with a pale under surface, and in the stouter aments. Possibly, however, it may be nothing but a form of var. *stipulacea*.

(?) 3×6. S. GOODDINGII×S. BONPLANDIANA (vel spec. nov. ?).—Southern Lower California: La Paz, January 20 to February 5, 1890, *E. Palmer* (no. 77, m.; W.); same locality, June 14, 1897, *J. N. Rose* (no. 1308, m.; W.).

The first specimen is named *S. Bonplandiana* var. *pallida*, the second *S. Bonplandiana*, but both do not represent the type or a form of this species

on account of the presence of stomata in the upper epidermis of the leaves. They look to me like hybrids between this species and *S. Gooddingii*, but I do not know whether the last species ever has been found so far south in Lower California. Instead of it one of the parents with stomata in the upper surface of the leaves may be *S. nigra* var. *Lindheimerii* (or even *S. Humboldtiana stipulacea*). The male flowers are very similar to those of *S. Bonplandiana*, the young branchlets and leaves are more or less pubescent (in no. 77 laxe subhirsuto-villosa), and the under surface of the (not yet mature) leaves is but slightly glaucous. Owing to the lack of female material, it is impossible to judge the form more correctly.

SALIX (?), spec. nov.—Territorio de Tepic, in the Sierra Madre, near Santa Teresa, August 11, 1897, *J. N. Rose* (st.; W.). These sterile branchlets seem to belong to a new species related to *S. Schaffnerii*, and may be described as follows: Ramuli hornotini apice pubescentia villosula griseo-brunnea vestiti, citissime glabrescentes et basim versus intense purpurascentes, glabri. Folia matura chartacea, anguste lanceolata, utrinque acuta vel apice subacuminata, minima 3:0.6 cm., maxima ad 9:1.2 cm. magna, dense glanduloso-subserrato-denticulata, superne initio sparse puberula, cito glabra, intense viridia, costa nervisque subflavescentibus, subtus albescentia, pruinosa, initio densius pilosa, dein fere glabra, costa nervisque elevatis et reticulata. Petioli vix 5 mm. longi, superne sulcati et pilosuli.

ARNOLD ARBORETUM

ALGAE OF THE HAWAIIAN ARCHIPELAGO. I

VAUGHAN MACCAUGHEY

The algae, particularly the seaweeds, of the Hawaiian Islands have attracted the attention of investigators for many years. In 1876 NORDSTEDT published a report upon the collections of BERGGREN ("De Algae aquae dulcis et de Characeis ex insulis Sandvicensibus a Sv. BERGGREN 1875 reportatis").

In 1881 a small list entitled "The algae of the Hawaiian Islands," by J. E. CHAMBERLAIN, appeared in THRUM'S *Hawaiian Almanac and Annual* for that year. In 1899 REINBOLD reported upon the collections of SCHAUINSLAND ("Meersealgen. Ergebnisse einer Reise nach dem Pacific; H. SCHAUINSLAND 1896–97." Abhandl. Naturw. Vereins Bremen 1899). The collector SCHAUINSLAND spent three months on the island of Laysan and made extensive collections of the algae of that island, of Oahu, and of the plankton between Oahu and Laysan. In 1901 Miss JOSEPHINE E. TILDEN published a popular article on "Algae collecting in the Hawaiian Islands" in *Postelsia*. This was an informal narrative of the visit made by herself and two other ladies to the islands in 1900. In 1902 Miss TILDEN published, in THRUM'S *Hawaiian Annual*, a list of 100 species entitled "Collection of algae from the Hawaiian Islands." In 1905 Miss MINNIE REED, science teacher at the Kamehameha Schools in Honolulu, published a valuable report in the *Annual Report of the Hawaii Agricultural Experiment Station*, entitled "The economic seaweeds of Hawaii and their food value."

In 1905 F. BRAND published "Anheftung der Cladophoraceen und über verschiedene polynesische Formen dieser Familie" (Beih. Bot. Centralbl. **18**:165–193). In 1905 E. LEMMERMANN published a very comprehensive paper ("Die Algenflora der Sandwich-Inseln," Bot. Jahrb. **35**:607–663), including plankton studies, and full records of the collections of SCHAUINSLAND.

In 1905 W. A. SETCHELL, who had made a short visit to the islands, published a paper on "Limu" (the Hawaiian word for seaweeds) in Univ. Cal. Pub. Bot. **2**:91–113. In 1910 Miss

TILDEN, in her "Minnesota algae, vol. I. Myxophyceae of North America," etc., included all available records of Hawaiian species and their distribution. In 1911 F. K. BUTTERS published "Notes on the species of *Liagora* and *Galaxaura* of the central Pacific" (Minn. Bot. Studies **4**:161–184). In 1917 the writer published a paper on "The seaweeds of Hawaii" (Amer. Jour. Bot. **8**:474–479. 1916).

The present paper is an effort to coordinate in a somewhat comprehensive and systematic form the scattered researches of nearly half a century, and to emphasize the ecological aspects of the Hawaiian algae. During a residence of 10 years in the islands the author has had opportunity to visit all of the larger islands, and to study the various algae habitats, from dredging operations along the reefs at a depth of 20 fathoms, up to the highest summits in the archipelago (nearly 14,000 ft.). His studies are incorporated in the present paper, but liberal use has been made of the investigations of others, particularly those of TILDEN, REED, and LEMMERMANN, to whom full credit is given for their pioneer labors.

Coral reefs

Because of their conspicuous situation along the coral reefs, large size, and economic value to the natives, the algae of the marine benthos flora have attracted particular attention. Seventy-five species, representing at least 40 genera, were habitually used for food by the ancient Hawaiians, and for these the natives had distinctive names.

Notwithstanding the relatively rich alga flora of the coral reefs, SCHIMPER's statement that "in opposition to the terrestrial tropical marine vegetation is less luxuriant and apparently less rich in forms than is that of the temperate and polar regions" holds true for the Hawaiian Islands. Moreover, the rockweeds, kelps, and laminarias that dominate the coasts of the cold countries are conspicuously absent from the Hawaiian flora. The distribution of the Hawaiian marine algae is intimately associated with the coastal topography and the development of the coral reefs and shallows. The older islands of the group, which are also the lowest, owing to the combined action of erosion and subsidence, have the

most extensive coral reefs. At the other extreme stands Hawaii, the youngest, highest, and largest island in the archipelago, with practically no lowlands or coral beaches, and very little reef coral.

The oldest islands of the series are the tiny reefs and shoals dotted along an axis 1800 miles long, lying to the west of the main group. Although of little commercial value, and with a combined area of only 6 square miles, these little islands are of great interest from the standpoint of their alga flora. Nihoa, French Frigates Shoal, and Gardner are eroded volcanic blocks, 170–900 ft. high, rimmed with fringing coral. Laysan and Lisianski are elevated coral islands, 45–55 ft., with fringing reef. Pearl and Hermes, Midway, and Ocean are typical coral atolls. Maro and Dowsett's reefs have visible surf, but no exposed coral. The entire series, named in sequence from east to west, is Nihoa, Necker, French Frigates Shoal, Gardner, Dowsett's Reef, Maro Reef, Laysan, Lisianski, Pearl and Hermes Reef, Midway, Ocean. SCHAUINSLAND[1] spent three months on Laysan and made extensive collections of the marine flora, both plankton and larger forms, but no thorough explorations have been made of the algae on the other isles and reefs.[2] When such an exploration, or series of explorations, is made, there is not the slightest doubt that a large number of new forms will be revealed, and that very important contributions will be made to the algology of the Central Pacific region. The significant feature of this long chain of tiny islets is that it undoubtedly represents the various stages in the subsidence of a titanic submarine mountain chain.

Some of the representative forms collected by SCHAUINSLAND at Laysan, and therefore to be expected along the shores and in the lagoons of others of these westward isles, are *Chondrocystis Schaunslandii*, *Gomphospharia aponina*, *Coleosphaeriopsis halophila*, *Xenococcus laysanensis*, *Oscillatoria bonnemaisonii*, *Spirulina subtilissima*, *Phormidium laysanense*, *Lyngbya mucicola*, *L. meneghiniana*, *Aulosira Schaunslandii*, *Caulerpa pinnata*, *Stypopodium lobatum*, and *Liagora coarctata*.

[1] SCHAUINSLAND, H. H., Drei Monate auf einer Korallen Inseln. Bremen. 1899.

[2] MACCAUGHEY, VAUGHAN, The little end of Hawaii. Jour. Geog. **15**:23–26. 1916; also Outstanding biological features of the Hawaiian Archipelago, in press.

KAUAI AND OAHU

Of the larger eastward islands, Kauai and Oahu are of particular note, as they have the largest coral reefs and support the most luxuriant marine flora. The reefs are all of the fringing and platform types, and vary in width from a few hundred feet to half a mile. Reefs are well developed along the southern or leeward shores of the two islands, and also, to a less degree, along the northern coasts. Oahu is practically encircled by coral, whereas Kauai has numerous coastal stretches entirely free from coral. The little island of Niihau, to the west of Kauai, has considerable coral reef. There are a number of regions along the Oahu coast which are especially favorable for collecting marine algae and for the study of their ecology. These are (1) the Waikiki region, between Honolulu Harbor and Diamond Head; (2) the Pearl Harbor region; (3) the Coral Plain and reef south of Ewa, between Pearl Harbor and Barber's Point; (4) the Waianae coast, which has extensive and well protected reefs; (5) the Wai-alua coast, which is not as well protected as that of Waianae; (6) the Kahuku region, with large sandy beaches and shoals; (7) the Ka-hana region, with drowned valleys and crescentic beaches; (8) Kane-ohe Bay, a beautiful body of water, 8 miles long and 3 miles wide, filled with coral islands and shoals; (9) Kai-lua and Wai-manalo, with lovely coral beaches and reefs; (10) the Koko Head and Mauna Loa district, with broad reef platforms half a mile wide. Most of the collecting by visiting algologists (TILDEN, SCHAUINSLAND, BERGGREN, etc.) was done along the Waikiki reefs, and also at Waianae. It has been the privilege of the author to visit repeatedly all of the reefs enumerated.

The following popular account[3] of a visit to a coral reef will serve to indicate the general features of this interesting life region.

> Arriving at a suitable location, where the water was only two or three feet deep, we anchored the canoe and prepared for wading. We were equipped with old shoes to protect our feet from the jagged, broken coral branches (which cause very painful and slow-healing wounds); with broad-rimmed hats to protect eyes, face, and neck from the intense glare of the sun and water;

[3] MACCAUGHEY, VAUGHAN, Coral reefs of the Hawaiian Islands. Jour. Geog. **14**:252–255. 1916; also A survey of the Hawaiian coral reefs, in press.

with geological hammers for breaking off fragments of coral; and with sundry haversacks, bottles, wide-mouth vials, etc. With our water boxes as guides we wandered for three delightful hours over the ledges, knolls, and sandy pockets of the reef; collecting, exploring, and rejoicing in the luxuriant abundance of marine life of every form and color. Branches of living coral; many kinds of curiously shaped shells; bright spotted crabs and crustaceans of various sizes; spiny sea-urchins; spidery-armed brittle-stars; exquisitely beautiful hydroid colonies; purple and black sea-cucumbers; delicate marine algae of many genera, reds, browns, olives, and greens of varying tints, a kaleidoscopic succession of queer marine organisms.

ECOLOGICAL ZONES ON REEF

The typical fringing reef exhibits 5 distinct zones or areas of plant and animal life. This zonation is best developed on the reefs with wide lagoons and a well defined outer margin or rim.

1. *Beach or inshore waters.*—The shallow inshore waters, varying in depth from 6 to 36 inches, sustain a number of the quiet water forms, such as *Enteromorpha* spp., *Hypnea nidifica*, *Gracilaria coronopifolia*, *Chaetomorpha antennina*, *Ulva* spp., *Chondria* spp., *Liagora decussata*, etc. The bottom is of coral sand or mud, more or less contaminated with volcanic wash from the mountains. The nature of the bottom depends upon the proximity of streams and the strength of the surf. In many places (Kai-lua, Mo-kapu, Mana) the bottom is pure white coral sand, with practically no mud or rock. In other districts (Kalihi, Nu'u-anu, Kane-ohe) there are large "mud flats" exposed at low tide, and the bottom here is very muddy and rocky, with little sand. Every gradation may be found between these two extremes. At the mouths of streams, and at other places along the coasts where fresh water springs exist below the tide level, the inshore water is sufficiently brackish to prohibit the development of the strictly marine species.

2. *Partially submerged rocks.*—In some places the beach and shallow waters are devoid of rock masses, but as a general condition one finds partially submerged rocks scattered all along the coasts. These may be either close inshore, in the form of ledges or little cliffs, or may lie at varying distances from the shore. In any case they distinctly indicate, by their horizontal bandings of algal and hydroid life, the ranges of high and low tide. These rock masses

are either of consolidated reef coral or of black basaltic lava. Some algal species show a preference for the coral (*Sargassum*, *Gracilaria*, *Laurencia*), others for the lava blocks (*Gelidium*, *Ahnfeldtia*, etc.). The rocks may be in somewhat protected situations, or may be exposed to the full force of the surf. The alga flora will depend largely upon the situation of the rocks with reference to the surf. The following kinds occur on rocks which are exposed to the continual battering of the surf: *Gymnogrongus* spp., *Asparagopsis Sanfordiana*, *Codium* spp., *Sargassum* spp., *Dictyota acutiloba*, *Haliseris plagiogramma*, *Gelidium* spp., *Ahnfeldtia concinna*, *Porphyra leucosticta*. The controlling factor in the alga flora of the partially submerged rocks seems to be the circulation of pure, well oxygenated sea water. Rocks in stagnant or impure water support a scanty flora as compared with those in surf-swept localities.

3. *Pools.*—Passing out beyond the rock litter we come to a zone characterized by numerous pools or pockets. These cuplike depressions in the lagoon floor vary in size from little pockets a meter in depth and diameter to large pools 5–10 m. in depth and diameter. The pools are easily distinguished by the darker tint of their waters as contrasted with that of the shallow lagoon. These pools in the floor of the lagoon are not to be confused with the "tidal pools" along the beaches. The lagoon pools are inhabited by a variety of algae and animals that prefer these shadowy havens to the exposure of the shallows or the outer reef. The bottom of the pool may be covered with clear coral sand, or coral débris, or masses of growing coral; its alga flora will depend upon its depth and the resultant intensity of illumination.

The following are typical forms that inhabit the lagoon pools: *Lithothamnion* spp., *Corallina* spp., *Peyssonnelia rubra*, *Grateloupia filicina*, *Ceramium clavulatum*, *Amansia glomerata*, *Polysiphonia* spp., *Chondria tenuissima*, *Laurencia* spp., *Martensia flabelliformis*, *Champia compressa*, *Wrangelia penicillata*, *Galaxaura lapidescens*, *Padina pavonia*, *Sphacelaria furcigera*, *Hydroclathrus cancellatus*.

4. *Lagoon.*—The entire region between the beach line or strand and the seaward rim of the reef is properly the lagoon, but for the purposes of this paper the term will be restricted to the deeper waters, which usually lie about midway between the beach and the

reef rim. As one approaches the lagoon, wading is no longer possible, the water is 3–10 m. or more deep, but again becomes shallower as the outer edge of the reef is reached. The water of the lagoon is placid, clear, and very transparent, so that the bottom receives good illumination. Although a number of the smaller algae grow upon the floor of the lagoon, the region is comparatively barren as compared with the shallower waters on either side. The lagoon floor is a region of coralline and animal life, rather than of the larger plant life. The quantities of sand that are constantly washed over the floor from the disintegrating reef rim render it difficult for plants to maintain themselves. Probably if conditions for collecting on the lagoon floor were more favorable, a larger number of species would be found than are apparently present.

5. *Reef rim.*—Upon rowing across the lagoon to the outer rim of the reef, one comes to shallow water, where the surf breaks, and where wading is possible. This zone is a favorite fishing ground of the native Hawaiians, and it abounds with both animal and plant life. The highest portions of the rim may be practically exposed at low tide, although at high tide they will be covered by 18–24 inches of water. The rim of the reef is by no means regular or symmetrical; there are many indentations, crags, débris slopes, pools, hummocks, and sandy spots all along the outer margin. Almost all of the visible coral in this region is living coral, associated with an abundance of corallines, bryozoans, hydroids, red algae, and other forms of life. Some of the algae that are confined largely to the outer reef rim are *Haliseris*, *Dictyota*, *Codium*, *Asparagopsis*, *Gymnogongrus*, *Porphyra*, *Turbinaria*, *Gelidium*, etc. Many of the species that inhabit these surf-churned waters are not the tough, cartilaginous forms, but very delicate and fragile species, that apparently survive the wave action because of their very delicacy. This is particularly true of some of the finer red algae.

TIDES

The situation of the Hawaiian Islands, in the great stretches of the North Pacific, is such that the tides are very small; in contrast with the tides usual along continental coasts they are exceedingly small. The average rise and fall lies within a vertical range

of 18–24 inches. The difference between high and low tide is so small that there is almost a complete absence of the strongly developed tidal zonation so characteristic of many continental shores. However, on the broad platform reefs, like those near Pearl Harbor, Waialae, and Mauna-lua, this difference is sufficient to expose much of the reef surface at low tide. At this time the reef consists of an irregular series of pools, cut off from one another by the rocky platform, which has only 2–3 inches of water on it. Protruding areas of the reef are wholly exposed to the air, and on their knobs or knolls only the hardy species of algae can exist. Out toward the edge of the reef a shallow lagoon, or series of lagoons, may persist, unemptied by the lowest tides. This is the ideal time for collecting, as one can travel afoot far out to the rim of the reef and easily procure material which at high tide is hidden beneath the surf and foam. To get the full advantage of the low tide one customarily begins work when the tide is about half run out, and then follows the ebb out to its maximum. This gives a working period of 4–5 hours.

CORALLINE ALGAE

Highly important among the Hawaiian marine algae are the coralline or "stony" algae or nullipores. A number of genera (*Lithothamnion*, *Corallina*, *Mastophora*, and others) are abundant on the Hawaiian reefs, and have undoubtedly been highly effective in reef building. The importance of these lime-secreting algae was overlooked by the earlier students of the coral reefs, but is now beginning to receive adequate consideration. As MAYER[4] states:

> The most striking feature which distinguishes the Pacific reefs is the development of a ridge which actually projects half a foot or more above low tide level and extends along the outer seaward edge of the reef-wall wherever the breakers dash. In the Paumotus this ridge is dull reddish pink in color, and it is composed of a mass of stony seaweeds or nullipores of the sort called *Lithothamnion*, and also of bryozoa which are remarkable lime-secreting organisms related more closely to the worms than to any other form of the animal kingdom.
>
> This *Lithothamnion* ridge thrives only where the breakers strike in full force upon its living barrier, and it serves as the chief protector of the island, breaking the force of every wave that approaches the windward shore.

[4] Popular Science Monthly **85**: 209–231. 1914.

HOWE,[5] in a digest of our present knowledge of the lime-secreting algae as reef makers, shows that in the famous boring at Funafuti, which was driven to a depth of 114.5 ft., *Lithothamnion* was found to be more or less abundant through the entire length of the boring; *Halimeda* was locally very abundant from 28 to 1096 ft. According to the same paper *Lithothamnion* is now recognized to be a dominant reef builder in the reefs of Fiji, Gilberts, Dutch East Indies, Bermudas, and other groups.[6] He states that the lime-secreting seaweeds flourish and are effective reef builders in greater depths than is the case with corals. There are numerous records of these forms at depths of 100 fathoms, *in situ*, and occasionally at 250–350 fathoms, whereas 25–40 fathoms is the greatest depth attained by the reef-building corals. HOWE continues:

> Besides flourishing in greater depths than the corals, the lime-secreting seaweeds are much less dependent upon high temperatures than are the corals. . . . . The coralline algae are, locally at least, abundant from 73°5′ south latitude to 79°56′ north latitude. . . . . He specifies the seas off the coasts of Spitzenberg, Nova Zembla, Iceland, Greenland, and Norway, where banks of *Lithothamnion* cover the bottom for areas of many square miles. . . . . The massive beds of *Halimeda opuntia* off the Florida Keys (the same species . . . . that is filling the lagoons of some of the South Sea atolls) are striking, as are the banks of *Goniolithon strictum* in the Bahamas, and reefs of *Lithophyllum antillarum* and *L. daedaleum* along the shores of Porto Rico. . . . . The lime-secreting plants appear to be much more generally and widely distributed, both horizontally and vertically, than are the corals.

The Hawaiian corallines inhabit the shallow waters, as well as occurring at considerable depths. In the former situations they form beautiful rose, purple, and lavender incrustations. On the faces of cliffs that are washed by the sea the incrustation appears as a conspicuous rose or purple band, extending from high tide mark or the uppermost wash of the surf, down to the zone of minimum illumination. The lower margin of the coralline zone has not been investigated in the Hawaiian Islands, but it undoubtedly reaches as great depths as in the island groups already cited. The upper margin is often somewhat above high tide mark, as these

[5] HOWE, M. A., Building of coral reefs. Science, N.S. **35**:837–842. 1912.

[6] See also SEWARD, A. C., Algae as rock-building organisms. Science Progress **2**:10–26. 1894.

algae are able to live even if they receive only intermittent spray wash. In this coralline zone are many of the calcareous hydrozoa.

TIDAL POOLS

Along the rocky coasts, where there are extensive shelves or ledges of lava or uplifted coral limestone, tidal pools are of common occurrence. The pools that lie nearest the water line are filled at every tide; indeed, many lose their identity as pools at each tide. Those at higher levels, and farther from the water line, may be filled only at times of very heavy surf, and dry up for considerable intervals. These variable conditions greatly affect the alga flora. The pools vary in size from mere puddles to large basins 10–20 m. long and 3–5 m. in depth. These large perennial basins support an alga flora very similar to that of the shallow lagoon waters. Excellent examples of tidal pools occur along the southern coast of Kauai, the Maka-pu'u region of Oahu, the north coast of Molokai and Maui, and along the Kona coast of Hawaii. Some of the algae common in the ordinary tidal pools are species of *Limnothamnion*, *Wrangelia*, *Liagora*, *Padina*, *Ectocarpus*, *Sphacelaria*, *Halimeda*, *Caulerpa*, *Cladaphora*, *Chaetomorpha*, *Enteromorpha*, *Monostroma*, *Calothrix*, *Scytonema*, *Hormothamnion*, *Hydrocoleus*, *Lyngbya*, *Phormidium*, *Oscillatoria*, etc.

CORAL REEFS ON OTHER ISLANDS

Special mention has been made of the reefs of Kauai and Oahu. The islands of Molokai, Maui, Lanai, and Ka-hoo-lawe all possess some coral reefs, but nowhere is the development of the alga flora as great as upon Oahu. The island of Molokai, both windward and leeward sides, ranks first among the 4 islands enumerated. The island of Hawaii, with an area larger than the combined area of all the other islands, is the poorest in marine algae. In fresh water species, however, it takes precedence over several of the smaller islands. The coasts of Hawaii are rugged and precipitous, and the deep offshore waters are not favorable for algae.

Taro loi and rice fields

Turning now to the habitats of the fresh water flora, we consider first the taro loi. The Hawaiians and Chinese raise the taro plant

(*Colocasia esculenta*) in irrigated patches called "loi." These are located on the lowlands and valley floors. Water is skilfully diverted from the mountain streams, and spread in a thin sheet over the loi. These tiny fields are each only a fraction of an acre in area, and many are only 20–30 ft. each way. The bottoms and low retaining embankments are composed of black volcanic alluvium. The loi are not continuously under water, but are flooded only at certain stages in the development of the taro. In this way each loi is at one time a shallow pond 6–12 inches in depth, at another a sheet of very soft, water saturated mud, and at another a sheet of fairly compact mud. These loi are notable habitats for the various fresh water algae, which occur in great variety and luxuriance. The algae may be found, according to their specific habitats, either floating on the surface of the water, free swimming in the water, growing upon the muddy bottom, epiphytic upon the stems of aquatic plants, or growing along the moist margins of the embankments, near the water's edge.

In recent years many of the taro patches have been converted into rice fields by the Chinese. The general conditions of irrigation, so far as influencing the alga flora are concerned, are practically the same for the rice as for the taro. Luxuriant growths of many fresh water species may be found in the rice fields. Some of the representative species occurring in these situations are as follows:

FLOATING AND FREE SWIMMING.—*Chroococcus, Raphidium, Scenedesmus, Glocothece, Aphanothece, Merismopodium, Xenococcus, Lyngbya, Anabaena, Scytonema, Hydrodictyon, Conferva, Ulothrix, Cladophora, Spirogyra*, etc.

EPIPHYTIC.—*Chamaesiphon, Lyngbya, Coleochaete*, etc.

ON BOTTOM OR MARGIN.—*Lyngbya, Nostoc, Anabaena, Scytonema, Stigonema, Calothrix, Rivularia, Gobium, Draparnaldia, Oedogonium, Bulbochaete, Nitella, Chara, Mougeotia, Zygnema*, etc.

Ditches and flumes

A habitat for many kinds of algae is the irrigation ditch or flume. The very general use in the islands of irrigation water for the raising of taro, rice, sugar cane, and other crops has led to the development of elaborate systems of ditches and flumes. The inner walls and margins of these water channels support a diversified algal flora, despite the intermittent nature of the water supply. Many of the flumes are constructed of rough wooden planking,

which often has sufficient leakage to stimulate extensive algal growths, either pendent from the under side of the flume or in the drip zone beneath it. Genera that are of frequent occurrence in the ditches and flumes are *Gloeocapsa*, *Aphanothece*, *Oscillatoria*, *Spirulina*, *Phormidium*, *Lyngbya*, *Nostoc*, *Anabaena*, *Cylindrospermum*, *Scytonema*, *Tolypothrix*, *Ulothrix*, *Stigeoclonium*, *Nitella*, *Chara*, *Zygnema*, *Spirogyra*, etc.

Caves

There are many caves in the Hawaiian mountains. Some are of vast size, but the majority are relatively small. They occur at all elevations, from sea level to the highest summits, and are invariably due to volcanic activity in former times. Many contain pools of water; those at sea level frequently have salt or brackish water. The walls of the cave are usually moist, especially around the mouth, due to seepage from above. The conditions of continuous moisture and sufficient light, which prevail near the mouth of the cave, are favorable for the development of algae. Luxuriant growths, particularly of the Cyanophyceae, occur in these places. Representative species which inhabit these localities are *Gloeocapsa quaternata*, *Aphanothece Naegeli*, *Oscillatoria sancta*, *O. formosa*, *Spirulina major*, *Phormidium papyraceum*, *Nostoc* spp., *Anabaena variabilis*, *Scytonema varium*, *S. ocellatum*, *Fischerella ambigua*, *Characium minutum*, *Ulothrix minutula*.

Some typical Hawaiian caverns which support an abundant algal flora are those of Ha-ena, Kauai; Nu'u-anu, Manoa, and Maka-pu'u, Oahu; Kau-po region of Hale-a-ka-la, and Hana region, Maui; Hilo and Ka-u regions of Hawaii. Innumerable smaller caverns are scattered throughout the mountainous regions of all the islands.

Mountain streams

The rainfall on the upper slopes (2500–6000 ft.) of the Hawaiian mountains is torrential. This has carved deep valleys, penetrating into the heart of the mountains. These valleys vary in length from a mile to 10–12 miles. In width they range from narrow, rock-walled, sunless gorges to great amphitheaters, several miles in diameter, and rimmed by tremendous precipices. In the floor of each valley is a narrow stream, rarely more than 12 ft. in width.

The slope of most the valleys is so steep, and the drainage basin so restricted, that the run off is extremely rapid, and the fluctuations in stream volume are very pronounced. The upper course of the stream, through the rain forest, is littered with large lava boulders, dotted with small pools, and interrupted by numerous cascades. The waterfalls vary in height from a few feet to 1500 ft. These mountain streams, owing to their intermittent nature, are not very favorable for the algae, and luxuriant growth is rare. The contrast between the abundant algal flora of a flooded taro loi or rice field, on the warm lowlands, and the paucity of forms inhabiting a cold, intermittent mountain stream, is very striking. On the other hand, although the algae are not abundant, they are present in moderate quantities and in considerable diversity.

On the moist earth along the banks of the stream, on the rocks in the bed itself, and in the frequent pools one finds such algae as *Gleocapsa quaternata*, *Aphanothece Naegeli*, *Phormidium*, *Lyngbya*, *Anabaena*, *Scytonema rivulare*, *Tolypothrix distorta*, *Dactylococcus infusionum*, *Dictyosphaerium pulchellum*, *Raphidium polymorphum*, *Pediastrum*, *Conferva*, *Ulothrix*, *Stigeoclonium*, *Draparnaldia macrocladia*, *Oedogonium*, *Bulbochaete*, *Cladophora nitida*, *Nitella haviensis*, *Xenococcus Kerneri*, *Characium groenlandicum*, *Closteriopsis longissima*, *Schroederia setigera*, *Salpinocoeca minuta*, *Dinobryon sertularia*, *Hemidinium nasatum*, *Asterionella formosa*, *Triploceros*, *Melosira*, *Cyclotella*, *Cymatopleura*, etc. The faces of the waterfalls, and the dripping cliffs immediately adjacent, are the habitats of such forms as *Gloeocapsa magma*, *Oscillatoria* spp., *Spirulina major*, *Nostoc* spp., *Scytonema varium*, etc.

Hot springs and thermal waters

The only waters in the Hawaiian Archipelago that have temperatures higher than that of the atmosphere are those in the vicinity of the active volcano Kilauea, Hawaii. There are a number of warm pools and springs in the Puna district, and these evidently all receive their heat from the subterranean molten lavas of Kilauea. The temperatures of these waters vary between 30 and 35° C. These warm pools contain a luxuriant algal growth, especially in the form of a coating over the rocks that form the sides and floors of the pools. Representative thermal species are *Fischerella thermalis*,

Glococapsa thermalis, Haematococcus thermalis, Microcoleus paludosus, Plectonema nostocarum, Schizothrix havaiensis, Scytonema azureum.

Summit bogs

A type of habitat differing markedly from those that have been described are the five bogs which occur on the summits of Waiale-ale, Kauai, Ka-ala on Oahu, East Molokai, West Maui, and the Kohala Mountains of Hawaii.[7] These bogs lie at an elevation of 4000–6000 ft., in a zone of almost continuous cloud and rain. The annual precipitation in these regions amounts to several hundred inches, perhaps as high as 500. The soil is perpetually saturated, and is covered with a blanket of alpine sedges, rushes, grasses, mosses, and liverworts. In this substratum, and in the relatively small and infrequent pools that occur here and there on the surface of the bog, there is a considerable variety of algae. It is to be regretted that the alga flora of the summit bogs has not received careful investigation. The higher plants that inhabit these regions are mostly endemic species and varieties, and it is probable that a proportion of the algae would also prove to be endemics. The blue-greens are the dominant group.

Brackish waters

At various places along the coasts, but particularly where the larger streams empty into the sea, are areas of brackish water. These may be either the actual mouth of the stream itself, lagoons, or swamp lands. In any case, these waters are inhabited by species which differ both from the strictly fresh water forms on the one hand and the marine species on the other. Many of the brackish water forms are used by the Hawaiians as food. Typical forms of these waters are *Enteromorpha* spp., *Oedogonium obsoletum*, *Chaetomorpha pacifica*, *Cladaphora* spp., *Nitella havaiensis*, etc.

Halophytes

LEMMERMANN lists a few halophytes from the "Salt Lake" Crater of Moana-lua,[8] and from the Laysan lagoon, which is about

[7] MACCAUGHEY, VAUGHAN, Vegetation of the Hawaiian summit bogs. Amer. Bot. **22**:45–52. 1916.

[8] This is no longer highly saline, as an artesian well has been bored in its bottom, and the lake converted into a fish pond.

three times as salty as sea water. The species are *Amphora ovalis* var. *pediculis*, *Lyngbya mucicola*, *Nitzschia angularis*, and *Coleosphaeropsis halophila*. The Laysan lagoon is the only known place in the archipelago possessing water of greater salinity than that of the sea, although of course the evanescent tidal pools attain a high degree of salinity in their later stages.

Fish ponds

Many of the free floating and filamentous algae are very abundant in the "loko" or fish ponds. These are shallow waters along the coasts that have been cut off from the open sea by means of heavy stone walls. The wall usually extends out from the land in the form of a crescent, pierced here and there by grated openings or gates, which permit the passage of the tides and very small fish, but which effectually retain the larger fish. The water within the pond is not disturbed by the surf, and the life conditions are more tranquil than those of the lagoon or sea. In ancient times some of the loko were utilized by the Hawaiians for a crude kind of limu culture. *Enteromorpha* and other coarse filamentous forms often form extensive floating mats on the waters of the loko. These ponds are most numerous on the islands of Oahu and Molokai, and have a combined area of many hundreds of acres.

Phytoplankton

The author has made no studies of the Hawaiian phytoplankton and so can only summarize here the extensive studies of SCHAUINSLAND and LEMMERMANN. The totals given by the latter authority are as follows:

	In Pearl Harbor	Between Hawaii and Laysan	Open Roadstead at Laysan
Schizophyceae	0	7	0
Chlorophyceae	0	2	0
Silicoflagellatae	0	3	0
Peridiniales	11	29	4
Bacillariales	11	10	12
Totals	22	51	16

The number of species of the last two groups, excluding duplicates, was 33 Peridiniales and 31 Bacillariales. The Hawaiian waters await an exhaustive study of their plankton; such a study will undoubtedly bring to light much new material of great interest.

Deep water forms

There have been no large investigations of deep water forms in the vicinity of Hawaiian waters comparable to those made in other parts of the ocean. The Hawaiian Islands all slope off very abruptly into deep water. There is little evidence of shelves or platforms. The outer faces of the coral reefs are all very precipitous, in striking contrast with the gentle slope of the inner or lagoon face. By some geologists the islands have been compared to the summits of a row of obelisks. The inter-island channels are very deep. The following table will make clear the extensiveness of the deep waters in the immediate vicinity of the islands:

Channel between	Kauai and Oahu	1872	fathoms or	11,232	ft.
"	" Oahu and Molokai	384	"	2304	"
"	" Molokai and Maui	135	"	810	"
"	" Maui and Hawaii	1032	"	9192	"

Endemism

The endemism which is so striking a feature of the terrestrial flora is exhibited to only a very minor degree by the algae. It is difficult to make any very comprehensive statement on this subject, as our knowledge of the algal flora of other Pacific Islands is still very incomplete. The following are typical forms which may be considered endemic in the present status of our knowledge: *Corallina sandwicensis*, *Mastophora tenuis*, *Laurencia nidifica*, *Plocamium sandwicense*, *Sargassum obtusifolium*, *S. polyphyllum*, *S. densum*, *S. incisum*, *Zygnema spontaneum*, *Oedogonium globosum*, *Draparnaldia macrocladia*, *Conferva sandwicensis*. Most of the algae are either cosmopolitan species or else widely distributed in many tropical and subtropical waters.

College of Hawaii
Honolulu

WESTERN PLANT STUDIES. V

ÁVEN NELSON AND J. FRANCIS MACBRIDE

SISYRINCHIUM IDAHOENSE Bickn., var. **birameum** (Piper), n. comb.—*S. birameum* Piper Contrib. Nat. Herb. **11**:203. 1906.—This variety may be distinguished ordinarily by the presence on the plant of one or more branched stems. Professor J. K. HENRY of Vancouver has kindly sent us specimens of the species transitional to the variety. These are deposited in the Gray Herbarium under his no. 9056 and were secured June 27, 1916, near Alberni, Vancouver Island. He wrote regarding them "all growing together and sometimes in the same bunch."

Sisyrinchium boreale (Bickn.), n. comb.—*Hydastylus borealis* Bickn. Bull. Torr. Bot. Club **27**:378. 1900.—BICKNELL was surely justified in segregating this small-flowered inhabitant of inland lakes from the truly maritime large-flowered *S. californicum*. *H. brachypus* Bickn., *loc. cit.* 379, however, seems to be only a state of *S. californicum* that is unworthy any formal recognition.

Brodiaea coronaria (Salisb.), n. comb.—*Hookera coronaria* Salisb. Parad. Lond. *pl. 2*. 98. 1801; *B. grandiflora* Smith, Trans. Linn. Soc. **10**: *pl. 1*. 1811.—SMITH cites SALISBURY'S name as a synonym, and comparison of the plates shows that both authors had in mind the same plant.

Allium scissum, n. n.—*A. incisum* Nels. and Macbr. BOT. GAZ. **56**:470. 1913; not *A. incisum* Fomine in Monit. Jard. Bot. Tiflis **14**:52. 1909.

Trifolium Leibergii, n. sp.—Stems flexuous, 8–15 cm. high, 1–several from the summit of a woody taproot: petioles, leaves, and peduncles canescent with a dense covering of fine crinkly hairs: petioles 1–2.5 cm. long; leaflets obovate or subrotund, 1–1.5 cm. long, about 1 cm. broad, spinulose-serrate above the entire cuneate base: peduncles 1.5–2 cm. long; heads 1.5–2 cm. in diameter; flowers reflexed in age, distinctly pedicellate: calyx pubescent like the rest of the plant but the hairs longer and tangled; lobes linear-lanceolate, setaceous-acuminate at tip, nearly equal, thrice the

length of the tube, 3–4 mm. long: corolla purple; standard minutely crenulate at the rounded apex; tip of wings obtusish: pod pubescent like leaves; seeds 2.

This clover is most nearly related to *T. Lemmonii* Wats., but the remarkably long calyx teeth and the very different leaves and pubescence mark it as distinct. It is equally at variance, in these and other characters, with *T. gymnocarpon* Nutt. Miss McDERMOTT (N. Am. Trif. 194. 1910) regards *T. Lemmonii* as a variety of the latter. We are not certain as to the justification of this disposition, but these species are certainly more closely related to each other than to *T. Leibergii*. We have had the pleasure of designating many of LEIBERG's specimens as types. It seems fitting, therefore, to call this unique clover *T. Leibergii*, based on his no. 2344 (as represented in the Gray Herbarium) from serpentine dykes near Dewey, Oregon, June 21, 1896.

CLARKIA

In a former contribution (BOT. GAZ. **61**:31–32. 1916) we expressed the opinion that the genera *Phaeostoma*, *Godetia*, and *Clarkia* should be united, because when all the species concerned are considered it is possible to establish an unbroken series on the same characters relied upon to maintain the genera as distinct. JEPSON in his careful revision of *Godetia* (Univ. Calif. Publ. Bot. **2**:319–320. 1907) pointed out its technical weakness and, after citing several standard works in which the genus is recognized, he wrote "in favor of its retention it may be urged that the genus forms a group of species which is very compact, that it does not include doubtful species, and that its ecological characteristics, habitats, time of flowering, and pollination devices are exceedingly uniform." In our judgment the only argument advanced here which will be affected in any way by the reduction of *Godetia* to *Clarkia* is the statement that "the genus forms a group of species which is very compact." This will not be truly applicable until in reality these genera *are* merged. As they now stand, it is impossible to "key out" certain species, even in ENGLER and PRANTL'S *Die natürlichen Pflanzenfamilien*, a work cited by JEPSON as an argument in favor of the maintenance of *Godetia*. When united with *Clarkia*, however, we have a genus which, considered in its entirety, represents as definite and distinctive a unit as there is in the family. JEPSON seems to have realized how unreliable and artificial the generic

bounds in this group are, but apparently felt our hesitancy (BOT. GAZ. **61**:32. 1916) in discarding the well known name *Godetia*. In a discussion (*loc. cit.* 352) of *G. delicata* Abrams,[1] he states, "on account of the clawed petals, hairy ring at orifice of calyx tube, and smoothish capsules, this species serves to emphasize in a marked manner the close relation between *Godetia* and *Clarkia*. It is most nearly allied to *Clarkia rhomboidea*." In this connection it is interesting to note that another species, *G. biloba*,[2] which is one of the connecting links between the genera (cf. JEPSON, *loc. cit.* 319, and NELSON and MACBRIDE, *loc. cit.* 32), has been found by Mrs. BRANDEGEE (JEPSON, *loc. cit.* 323) to have hybridized with *Clarkia elegans*.

It is unfortunate that JEPSON did not make his critical revision more inclusive. In the citation of specimens particularly he seems to have eliminated collections from the Northwest. This makes the determinations of material from north of California more difficult than it should be. PIPER and BEATTIE's treatment in their recently published *Flora of the Northwest Coast* is helpful, but even it includes only 7 of the 13 species credited to the region. Accordingly it has seemed desirable in making the necessary transfers from *Godetia* to *Clarkia* to give, at the same time, a brief synopsis of the species.

Godetia tenella (Cav.) Steud. is not included; even the nature of the type seems to be very obscure (cf. JEPSON, *loc. cit.* 348). HOWELL'S *Fl. N. W. Am.* 235 contains *G. epilobioides* (Nutt.) Wats.[3] This distinctive species is confined to southern California (JEPSON, *loc. cit.* 343). Specimens so labeled from Oregon and Washington are usually referable to *G. gracilis* Piper. HOWELL does not include *G. grandiflora* Lindl.,[4] although the species was described from plants grown from supposedly Oregon seed. It seems to be known, however, only from the coastal region of central California. JEPSON (*loc. cit.* 348) reduces *Oenothera Whitneyi*

[1] **Clarkia delicata** (Abrams), n. comb.—*Godetia delicata* Abrams, Bull. Torr. Bot. Club **32**:539. 1905.

[2] **Clarkia biloba** (Durand), n. comb.—*Oenothera biloba* Durand, Pl. Pratt. 87. 1855; *Godetia biloba* (Durand) Wats. Bot. Cal. **1**:231. 1876.

[3] **Clarkia epilobioides** (Nutt.), n. comb.—*Oenothera epilobioides* Nutt. in T. and G. Fl. N. Am. **1**:511. 1840; *Godetia epilobioides* (Nutt.) Wats. Bot. Cal. **1**:231. 1876.

[4] **Clarkia superba,** n. n.—*Godetia grandiflora* Lindl. Bot. Reg. 27 Misc. 61. 1841, not *C. grandiflora* (F. and M.) Greene, Fl. Franciscana **2**:223. 1891.

Gray[5] to this species, but this is an error. LINDLEY's description of *G. grandiflora* reads "fructu lineari 4-sulcato tereti pubescenti." This description accords perfectly with the fruit of all collections we have seen. The capsules of GRAY's species, on the other hand, are far from linear, being thick and short, only 2 cm. long. JEPSON's description (*loc. cit.* 347, 348) of *G. grandiflora* applies rather to this species, and the specimens cited by him are referable here. In the following outline of the northwestern members of the genus *Clarkia* we have not cited specimens of the well known species.

Petals lobed, clawed ..... 1. *C. pulchella*
Petals entire or at least not lobed, sessile, or short clawed
  Stigmas linear; calyx lobes united and turned to one side in anthesis; capsules pedicelled or sessile
    Anthers 4–8 mm. long, more or less hooked or curved after dehiscence
      Buds usually erect; capsules sessile or subsessile, short beaked, teretish 2. *C. amoena*
      Buds nodding; capsules long pedicelled and long beaked, 8-ribbed 3. *C. arcuata*
    Anthers 3 mm. long, fertile to the tip, not becoming curved ... 4. *C. caurina*
  Stigmas short and broad; calyx lobes becoming free (except in no. 7); capsules sessile
    Capsules terete or nearly so and not prominently ribbed; flowers spicately scattered
      Leaves oblong to ovate ..... 5. *C. rhomboidea*
      Leaves linear
        Style only half as long as stamens; ovary densely white puberulent 6. *C. Romanzovii*
        Style nearly as long as stamens; ovary slightly puberulent 7. *C. gracilis*
    Capsules distinctly 4-sided or prominently ribbed; flowers (except in no. 8) in compact spikes or dense clusters
      Flowers scattered, the spikes usually long; petals 5–12 mm. long 8. *C. quadrivulnera*
      Flowers in dense clusters or if not the petals much larger
        Stems erect, not flattened
          Capsules pubescent; petals 1–3.5 cm. long
            Style as long as or longer than the stamens; capsules puberulent 9. *C. viminea*
            Style shorter than the long stamens; capsules usually shaggy-pubescent ..... 10. *C. purpurea*
          Capsules typically glabrous; petals less than 1.5 cm. long 11. *C. Arnottii*
        Stems decumbent-ascending, flattened above ..... 12. *C. decumbens*

[5] **Clarkia Whitneyi** (Gray), n. comb.—*Oenothera Whitneyi* Gray, Proc. Amer. Acad. **7**:340, 400. 1868.

1. CLARKIA PULCHELLA Pursh, Fl. 1:260. 1814.—It is not necessary to cite specimens of this beautiful and distinctive species. Its range is greater, however, than generally indicated in the books. Although most frequent from British Columbia to western Idaho and California, it crosses Montana and has been secured in the Black Hills of South Dakota. Often cultivated in the eastern states, it is of spasmodic occurrence there as a weed in newly seeded grounds, etc.

2. **Clarkia amoena** (Lehm.), n. comb.—*Oenothera amoena* Lehm. Ind. Sem. Hort. Hamb. 8. 1821.—This species and the next one are well marked by the character of the anthers curving after dehiscence. There is some variation in this, however, the cells sometimes being fertile to the tip and then tardily recoiling. Two noteworthy, but in themselves variable, color forms occur. These may be known as forma **concolor** (Jeps.), n. comb.—*Godetia amoena*, var. *concolor* Jeps. Fl. Mid. 334. 1901; and forma **Lindleyi** (Dougl.), n. comb.—*O. Lindleyi* Dougl. Hook. Bot. Mag. *pl. 2832*. 1828; *G. amoena*, var. *Lindleyi* Jeps. Univ. Cal. Publ. Bot. 2:329. 1907. The latter is distinguished by the presence of a dark central blotch in the petals.

Coastal region, British Columbia to Monterey County, California.—OREGON: Willamette River below Portland, June 10, 1902, *Sheldon*, S. 10864; Calapooya Creek, Douglas County, July 24, 1899, *Barber* 75 and 76.—WASHINGTON: Tacoma, 1894, *Miss J. H. Van Rensselaer;* Sinclair's Inlet, Kitsap County, July 1895, *Piper;* near Chenowith, Skamania County, June 16, 1892, *Suksdorf* 2129; between Olympia and Gate City, Thurston County, July 15, 1898, *A. A.* and *E. Gertrude Heller* 4051 (form with anthers fertile to apex).

3. **Clarkia arcuata** (Kell.), n. comb.—*Oenothera arcuata* Kell. Proc. Cal. Acad. 1:58. 1855; *Godetia hispidula* Wats. Proc. Am. Acad. 8:599. 1873; *G. arcuata* (Kell.) Jeps. Univ. Cal. Publ. Bot. 2:335. 1907.—HOWELL, Fl. N. W. Am. 235. 1900, credits this species to the Northwest, and he is followed by FRYE and RIGG, Elem. Fl. N. W. 159. 1914. JEPSON (*loc. cit.* 335 and 322), however, restricts its range to central California, and we have seen no specimens from Oregon.

4. **Clarkia caurina** (Abrams), n. comb.—*Godetia caurina* Abrams Contrib. Nat. Herb. 11:410. 1906.—Vancouver Island to western Washington.

5. CLARKIA RHOMBOIDEA Dougl. in Hook. Fl. Bor. Am. **1**:214. 1833.—*Phaeostoma rhomboidea* (Dougl.) A. Nels. BOT. GAZ. **52**:267. 1911.—Eastern Washington and Oregon, and adjacent Idaho to Utah, Nevada, and California.

6. **Clarkia Romanzovii** (Ledeb.), n. comb.—*Oenothera Romanzovii* Ledeb. ex Hornem. Hort. Hofn. Suppl. **1**:133. 1819; *Godetia Romanzovii* (Ledeb.) Spach, Hist. Veg. Phan. **4**:390. 1835.—This species has not been collected since originally by CHAMISSO on "the Northwest Coast," unless a specimen by ELMER from Port Angeles should be referred to it, as suggested by PIPER and BEATTIE (Fl. N. W. Coast 251. 1915). We have not seen this collection; there are, however, two authentic specimens of this species in the Gray Herbarium. One is from the "Hort. Soc. Lond." and the other is from the "Jardin des Plantes, 1837" and belonged to the Gray Herbarium. Both specimens are well preserved and agree with JEPSON'S description (Univ. Cal. Publ. Bot. **2**:349. 1907). PIPER and BEATTIE'S diagnosis is misleading, however, as the plants are not "densely white puberulent throughout" but only so on the young parts, as emphasized by JEPSON, where it is indeed "close and feltlike." Since the species has retained its salient characteristics for generations in cultivation (see JEPSON, *loc. cit.* 321), its rediscovery in a native state is highly probable. Accordingly it seems proper to give it recognition.

7. **Clarkia gracilis** (Piper), n. comb.—*Godetia gracilis* Piper, Piper and Beattie's Fl. N. W. Coast, 251. 1915.—Among our species this is nearest the next, from which it may be distinguished by the united calyx lobes, the tendency of the buds to nod, and the merely puberulent pods. This last character, however, is not dependable anywhere in the genus, as most species show great variation in this respect.

Vancouver Island to Oregon.—OREGON: Silverton, 1871, *Elihu Hall* 192; Tualitin, August 1880, *Joseph* and *Thomas J. Howell* 326; Grizzly Butte, Crook County, June 18, 1894, *Leiberg* 273.—WASHINGTON: Klickitat County, May 27, 1881, *Suksdorf* 23; Bingen, Klickitat County, May 18, 1906, *Suksdorf* 5606.—VANCOUVER ISLAND: Ball Mountain, June 17, 1907, *Rosendahl*, 1849.

8. **Clarkia quadrivulnera** (Dougl.), n. comb.—*Oenothera quadrivulnera* Dougl. in Lindl. Bot. Reg. *pl. 1119.* 1827; *Godetia*

quadrivulnera (Dougl.) Spach, Hist. Veg. Phan. **4**:389. 1855; *G. bingenensis* Suksd. Deutsch. Bot. Monatss. **18**:88. 1900.—Vancouver Island to California.

9. **Clarkia viminea** (Dougl.), n. comb.—*Oenothera viminea* Dougl. Bot. Mag. *pl. 2873*. 1828; *Godetia viminea* (Dougl.) Spach, Hist. Veg. Phan. **4**:389. 1835.

Western Oregon to California.—OREGON: Grant's Pass, Josephine County, June 23, 1884, *Howell;* Multnomah County, June, 1877, *Howell* 138 and 139; Coast Ranges, July 1882, *Howell* and *Henderson*.

10. **Clarkia purpurea** (Curtis), n. comb.—*Oenothera purpurea* (Curtis) Bot. Mag. *pl. 352*. 1795; *Godetia purpurea* (Curtis) Don in Smith Hort. Britt., ed. 3, 237. 1839.—HOWELL (Fl. N. W. Am. 234. 1900) includes this species, but the specimens we have seen have come from California, and JEPSON in his revision cites no collections from Oregon. *G. albescens* Lindley, however, was described from plants grown from seeds secured in Oregon by DYER, and since it is probably a form of *C. purpurea*, as suggested by JEPSON (*loc. cit.* 351), it seems advisable to credit the latter species to our flora. The congested inflorescence and generally very shaggy pods are salient characters that ordinarily mark the species at once.

11. **Clarkia Arnottii** (T. and G.), n. comb.—*Oenothera Arnottii* T. and G. Fl. N. Am. **1**:503. 1840; *Godetia Arnottii* (T. and G.) Walpers, Rep. **2**:88. 1843.—This species may usually be recognized easily by the glabrous capsules, but sometimes these are puberulent as in the specimen by SHELDON. Mrs. BRANDEGEE has collected both forms growing together in California. PIPER and BEATTIE (Fl. N. W. Coast 252. 1915) have not indicated this variation.

Oregon to California.—OREGON: Umpqua Valley, June 24, 1887, *Howell* 703; Lower Albina, Portland, July 21, 1902, *Sheldon*, S. 10975.

12. **Clarkia decumbens** (Dougl.), n. comb.—*Godetia decumbens* Dougl. Bot. Mag. *pl. 2889*. 1829; *G. lepida* Lindl., Bot. Reg. *pl. 1849*. 1836, not Howell, Fl. N. W. Am. 234. 1900, which is probably *C. purpurea* or *C. Arnottii*.—JEPSON has shown (*loc. cit.* 350) that the seeds of this plant were first gathered in Oregon. The present status of the species is comparable to that of *C. Romanzovii*,

and according to JEPSON garden specimens display with fidelity the type characters. There is an indigenous specimen, however, in the Gray Herbarium which answers perfectly JEPSON's characterization (*loc. cit.* 350). It bears no data other than "Wahlamet. Tolmie," and in GRAY's handwriting the name "*Oenothera decumbens*." The locality intended is, of course, the Willamette River, which at one time was spelled in several different ways, as, for example, "Wahlamutte" or "Wallamette."

Gentiana Covillei, n. sp.—Aspect of *G. calycosa* and *G. platypetala* to which it is closely related: stems 10–20 cm. high: leaves 6–10 pairs, at nodes gradually approximated upward, the last two pairs involucrating the solitary flower, broadly ovate to ovate-oblong, obtuse to sub-acute: calyx tube half as long as the corolla tube, doubly spathaceous in appearance, being split on opposite sides to the base, one valve bearing two and the other three small teeth, dark purplish-blue but membranous, the conspicuous veins terminating in the minute lance-cuspidate teeth: corolla dark blue, often with red or copper colored spots or blotches, 25–30 mm. long, broadly tubular-campanulate, the sub-oval or reniform lobes less than half as long as the tube, the margins obscurely crenulate-denticulate; the sinus plaits inconspicuous, being very low-triangular, about 1 mm. high: capsule as long as the corolla, stoutly oblong, obtuse, tapering at base to the short stout stipe: seeds 5 mm. long, very numerous, the body narrowly ovate, the excavated hilum sublateral and membranous apical appendage divergent.

In COVILLE's Report upon the Funston Collection at Yakutat, no. 108, Disenchantment Bay, is referred to *G. platypetala* with some reservation. WALKER's ample material in excellent condition is probably the same and shows that the calyx, the seeds, and the plaits are very different from *G. platypetala* as described by GRISEBACH. Since we are indebted to COVILLE's notes and description (Contrib. Nat. Herb. **3**:344. 1896) for the first accurate information concerning the species here named, we wish to dedicate it to him.

The type is *Walker* 935, secured at an altitude of 2000 ft. on grassy slopes above timberline, Mainland, Vixen Inlet, Alaska, August 20, 1915.

NEMOPHILA PEDUNCULATA Dougl., var. **sepulta** (Parish), n. comb.—*N. sepulta* Parish, Erythea **7**:93. 1893; *N. Menziesii* H. and A. var. *minutiflora* Suksd. Deutsch. Bot. Monatss. **8**:133.

1900; *N. sepulta* Parish, var. *minutiflora* (Suksd.) Brand, Pflanzenreich iv. **251**:52. 1913.—BRAND distinguishes this plant from *N. pedunculata* by the fewer-seeded capsules. The latter species normally has 3–6 ovules to each placenta, although frequently only 2–4 seeds are matured. A specific instance in which this occurs is *Baker* 914 from King's Canyon, Nevada, upon which BRAND bases his *N. pedunculata*, var. *Bakeri* Brand (*loc. cit.* 54). Unfortunately, at least some specimens of this collection show only capsules that mature two seeds. This great variation in the number of seeds matured makes it extremely difficult to distinguish the 4-ovuled and 6–12-ovuled forms, since they differ in no other respect and occupy the same range. In fact, they may even grow in close proximity, as illustrated by *Chandler* 6039 and 6037, both from Isabel Creek, Santa Clara County, California, the first representing the typical form and the latter the fewer-ovuled var. *sepulta*. Sometimes the variety has slightly larger flowers that are more or less dotted with dark markings. This form also occurs throughout the range of the typical state and may be known as

NEMOPHILA PEDUNCULATA Dougl., var. **densa** (Howell), n. comb.—*N. densa* Howell, Fl. N. W. Am. **1**:466. 1901; *N. sepulta* Parish, var. *densa* (Howell) Brand, *loc. cit.* 53; *N. nana* Eastw. Bull. Torr. Bot. Club **28**:151. 1901; *N. alata* Eastw., *loc. cit.* 158; *N. reticulata* Suksd. West Amer. Sci. **14**:32. 1903.

NEMOPHILA HETEROPHYLLA F. and M., var. **tenera** (Eastw.), n. comb.—*N. tenera* Eastw. Bull. Torr. Bot. Club **28**:153. 1901; *N. heterophylla* F. and M., subvar. *tenera* (Eastw.) Brand, Pflanzenreich iv. **251**:56. 1913; *N. nemorensis* Eastw., var. *glauca* (Eastw.) Brand, *loc. cit.* 57; *N. fallax* Eastw., *loc. cit.* 156.—CHANDLER (BOT. GAZ. **34**:211. 1902), in his very practical revision of this genus of extremely variable plants, included in one "species" the forms listed, together with *N. nemorensis* Eastw., which BRAND (*loc. cit.* 56) retains as a species distinct from *N. heterophylla*, including in it all specimens of this group which have linear or minute corolla appendages. Specimens with broad, often prominent, appendages in the corolla he refers to *N. heterophylla*. In doing this, however, he fails to show that the degree of development of the scales in the corolla possesses any value for purposes of

practical classification; on the contrary, his reduction of named forms based on the presence or absence or shape or size of the scales in the corolla substantiates CHANDLER's observations that the variations of these organs do not furnish suitable criteria for the determination of specific values. BRAND attempts to add weight to his maintenance of *N. nemorensis* by the following analysis of its range in relation to that of *N. heterophylla:* "Das Hauptverbreitungszentrum dieser Art scheint die Santa Clara County zu sein, während das der vorigen wohl die Mendocino County ist. In diesen beiden Counties kommt nur eine Art vor, wahrend in den mittleren Counties beide sich finden." This argument, however, loses its force upon the realization that, although these counties are separated by a distance of over 100 miles, they are equally in the coastal region of the state and enjoy essentially identical ecological conditions. Moreover, all the specimens from this region are very similar in foliage and pubescence, but the material secured in the interior portion of the state and in Oregon is almost always more densely pubescent and usually displays a tendency to have bipinnatifid leaves. Accordingly it seems desirable to recognize this inland state form as an ecological variant of the coastal plant, letting one varietal designation include all the forms of the interior regardless of the development of the scales in the corolla. Since BRAND indicated his subvar. *tenera* as being "Die Form des südlichen Oregon und der Sierra Nevada," this name may be retained for these plants.

NEMOPHILA PARVIFLORA Dougl., var. AUSTINAE (Eastw.) Brand, Pflanzenreich iv. **251**:55. 1913.—*N. explicata* Nels. and Macbr. BOT. GAZ. **55**:377. 1913 should be referred here.

PENTSTEMON PERPULCHER A. Nels. BOT. GAZ. **52**:273. 1911.—RYDBERG has expressed the opinion (Bull. Torr. Bot. Club **40**:482. 1913) that *P. perpulcher* and *P. unilateralis* Rydb., *loc. cit.* **33**:150. 1906, are the same. This assertion is strengthened by the statement that he has had the opportunity of comparing cotype material of the former with the type of the latter, "which is deposited in the herbarium of the New York Botanical Garden." This location of the type of *P. unilateralis* is rather puzzling in view of the fact that that species was said originally to be based on "*P. secundiflorus*

A. Gray, Syn. Fl. **2**:263. 1878, not *P. secundiflorus* Benth." Inasmuch as GRAY wrote his description from a specimen or specimens deposited in the Gray Herbarium, one of these collections must logically be taken as the type of *P. unilateralis*, and not a specimen arbitrarily set up as such in another institution. But to return to the question of the relationship of these species. In the first place, the status of *P. unilateralis* seems to depend primarily upon the value of the presence or absence of hair on the sterile stamen as a specific character. Most recent authors, including RYDBERG in his *Flora of Colorado* (306. 1906), have relied upon this character as a means of separating groups of species, and ordinarily it is doubtless of value, especially when accompanied by other characters, including distribution. Now according to RYDBERG'S key (*Fl. Colo.*), *P. secundiflorus* Gray and, in fact, *P. secundiflorus* Benth. (see DC. Prod. **10**:325. 1846), have the sterile stamen bearded at the tip, while in *P. unilateralis* Rydb. it is glabrous. But in *P. perpulcher* A. Nels. the sterile stamen is always bearded, yet RYDBERG would reduce the latter to his species. Obviously the reduction of *P. perpulcher* means the reduction of *P. unilateralis*, and indeed it is very doubtful whether the latter is specifically distinct from true *P. secundiflorus*, as the two forms grow in the same localities in Colorado and seem to possess no constant difference unless the sterile stamen character is reliable. But the case is much stronger for *P. perpulcher*. Both the other species are glabrous, the corollas average a good 2 cm. in length, and the plants range from Wyoming to northern New Mexico. *P. perpulcher* has only been collected in northwestern Idaho, but is frequent throughout that part of the state. Its foliage is decidedly puberulent and the corollas generally run less than 2 cm. in length. The puberulence is suggestive of *P. virgatus* Gray of New Mexico and Arizona, and in spite of the narrow leaves and glabrous sterile stamen of that species *P. perpulcher* is probably more nearly allied to it than to the Colorado species.

In BOT. GAZ. **55**:382. 1913 we proposed var. *pandus* to take care of a plant in which the puberulence extends throughout. We did not notice, however, that the sterile stamen is glabrous. Altogether this plant seems to be related rather to *P. virgatus*, although

it is far removed geographically and has the broad leaves and the aspect of *P. perpulcher*. Since this plant differs in the same manner from its allies as the species previously discussed, it seems advisable to consider it as a species, although further knowledge may show these characters to be of no consequence taxonomically. But in accord with our present interpretation var. *pandus* must become

P. pandus (Nels. and Macbr.), n. comb.—*P. perpulcher* A. Nels. var. *pandus* Nels. and Macbr. Bot Gaz. **55**:382. 1913.

Pentstemon Albrightii, A. Nels., n. sp.—Growing in small dense tufts, or often as single individuals, the crown or crowns furnished with coarse fibrous roots: leaves mostly basal, tufted on the crowns, glabrous, erect, 3–8 cm. long (including the petiole), spatulately oblanceolate, tapering gradually into the petiole, subacute or rounded at apex: stems one or more from each crown, scapose, the leaves if any remote and bractlike, sparsely floriferous for half their length or more, 1–2 dm. high, glabrous except in the inflorescence which becomes glandular pubescent upward: flowers in a more or less unilateral open raceme: calyx small, dark (greenish-purple), the lobes slightly unequal, as long or longer than the campanulate tube: corolla glabrous inside and out, a pale lavender, 9–13 mm. long, the tube slightly or not at all dilated, the limb short and abruptly spreading: sterile filament glabrous, slender, and much shorter than the others: anther cells confluent but not explanate: style as long as the corolla tube, stoutish, with small stigma.

This species is singular in its few-flowered, open, almost simple, secund racemose cyme. A few of its characters suggest the genus *Chionophila*, particularly its rosulate leaves, scapose stems, and greatly reduced sterile filament. The inflorescence is such, however, that the aspect of the plant as a whole is that of *Pentstemon*. The floral, fruit, and seed characters are also those of *Pentstemon*. It lacks those determinative characters of *Chionophila*, namely, the accrescent calyx, the marcescent corolla, and the large strongly angulate seeds.

It was first collected by J. F. Macbride, in 1910, in the Trinity Lake region of Idaho. Then it was secured by Dr. C. C. Albright, of Anaconda, Montana, in 1914, but both of these collections were inadequate and poor. It was tentatively named as given from Albright's material, but until now it has not seemed wise to publish. Fortunately, Macbride and Payson found it again in Idaho and secured an abundance of excellent material. Their no. 3570, from the Josephine Lakes, Custer County, is the type. They also

secured it on Parker Mountain, in the same county, no. 3237. It seems to be alpine, coming in just at timberline, among the straggling, dwarfed, depressed remnants of the forest and persisting for some hundreds of feet higher.

HAPLOPAPPUS EXIMIUS Hall, Univ. Cal. Publ. **6**:170. 1915.—It is refreshing to see technical papers so fully and painstakingly worked out as those by Professor H. M. HALL. He is so evidently fair that his arguments are unusually convincing. Nevertheless, in publishing this species he states so fully the differences that separate the *Haplopappus* segregates as to confirm (rather than otherwise) their validity. Those who take this view will think, therefore, that the name of the above plant should be **Tonestus eximius,** n. n.

Prenanthes hastata (Less.). n. n.—*Sonchus hastatus* Less. Linn. **6**:99, 1831; *Nabalus alatus* Hook. Fl. Bor. Amer. **1**:294. 1834.

CASTILLEJA MINIATA Dougl., var. **Dixonii** (Fernald), n. comb.—*C. Dixonii* Fernald Erythea **7**:122. 1899.—In BOT. GAZ. **61**:45. 1916 we noted the salient characteristics of *C. miniata* and its var. *crispula* (Piper) Nels. and Macbr. Recently our attention has been called to another variation by specimens sent us from Alberni, Vancouver Island, by Professor J. K. HENRY (his no. 9070 in the Gray Herbarium). These differ from typical material of *C. miniata* only in the very thick leaves. This maritime plant has been designated *C. Dixonii* (*loc. cit.*), the type being composed of decumbent or only slightly ascending plants that evidently represent the extreme condition of this variation. *Piper* 4957 from Ilwaco, Washington, is, like the *Henry* specimens, erect or nearly so. The coastal plants, therefore, seem to represent merely an ecological state of typical *C. miniata*, and may be treated varietally.

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NOTES ON OSMOTIC EXPERIMENTS WITH MARINE ALGAE[1]

RODNEY H. TRUE

During the summer of 1899, when the writer was engaged in plant physiological investigations at Woods Hole, he took the opportunity to study the osmotic properties of a number of algae from both fresh and marine waters. These studies were not complete, but since they shed some light on relations which still have much physiological interest, the results are here presented. Moreover, since that time, through the work of MORSE and his associates (**15**), BERKELEY and HARTLEY (**1, 2, 3**), and others, the recalculations of osmotic relationships have resulted in important changes. The bearing of the work of physicists on the problems of physiology has been pointed out by RENNER (**20**), who has done much to resolve the difficulties involved in the question. The osmotic values here dealt with have been calculated according to the newer methods. In some cases the values calculated according to PFEFFER'S (**18**) data are added in order to enable the reader to contrast the values obtained under the two methods of reckoning.

Osmotic pressure in Spirogyra cells

It was desired first to ascertain an approximate measure of the osmotic value of the sea water at Woods Hole. For this purpose some organism having a lower osmotic pressure than that of the sea water was sought. Several fresh water algae, *Spirogyra elongata*(?), *Zygnema* (sp.), and *Oedogonium* (sp.), found growing in a small fresh water pond between Woods Hole and Nobska Point, were tested.

Preliminary experiments with the distilled water available showed the presence of injurious impurities, probably copper from the still. The addition of shredded filter paper to the stock bottle was found to remove the pathological symptoms, and the solutions

[1] Published by permission of the Secretary of Agriculture.

used were made up with distilled water so treated. In all cases solutions were made up on the basis of the desired number of gram molecules of dry substance dissolved in water sufficient to make a liter of *solution*, that is, on the volume-normal basis.

In order to calibrate the indicator plants, solutions of cane sugar and of NaCl in a graduated series of concentrations were carefully prepared from high grade chemicals. These dilutions when in use were kept in covered beakers of 250 cc. capacity. The algae were quickly freed of surplus solution by the use of fresh filter paper before transfer, and freed from remaining traces of the solution by a quick rinsing in a duplicate portion of the solution into which they were to go. After the transfer, filaments were removed at definite intervals for microscopic examination, either on a watch glass or on a slide.

In determining the osmotic equivalent, some difficulty was experienced owing to the fact that all cells of the same filament did not show the same plasmolytic response to a given concentration. This difference was especially marked as the critical concentration was approached. As a rule the tip cells of a filament showed incipient plasmolysis in a weaker solution than did the other cells. Those that had lately undergone division seemed to plasmolyze more promptly as a rule. Since plasmolysis begins to take place only after the concentration of the outer medium is in excess of the concentration of the cell sap, in this study the osmotic end reaction was regarded as reached when the first traces of withdrawal of the protoplast were seen in the tip cells. Since the problem of absorption was not under investigation, the persistence of signs of plasmolysis was not studied. In order to avoid as far as possible complications due to the penetration of the materials from the solution under test, results seen within an hour after the application of the solutions in question were accepted. At times slight plasmolysis seen within this time would soon disappear. Obviously, therefore, the promptest possible registration of osmotic conditions would be expected to give the best evidence of conditions normally existing in the cell.

As a result of a series of tests made with cane sugar, it appeared that for a major part of normal *Spirogyra* and *Oedogonium* cells a concentration of 0.25 gm. molecules per liter of solution was just short of producing plasmolysis at 22°0 C. Only in the tip cells was

an undoubted "starting" of the protoplast from the wall seen. This appeared inside of 20 minutes and still persisted at the end of an hour, but was scarcely noticeable after 20 hours. The osmotic pressure of the cell contents of these algae was, therefore, very nearly equal to 0.25 gm. mol. of cane sugar in a liter of solution. In calculating this value in terms of atmospheres, the values of MORSE and FRAZER (**15**) were used. However, since MORSE's osmotic determinations were made on the basis of gram molecules dissolved in 1000 gm. of water, this value was reduced to the latter basis by means of RENNER's formula: $\frac{m \quad 1000}{1000-214m}$, m being the given number of gram molecules in 1000 ccm. of solution. The osmotic equivalent of the algae in question became, therefore, 0.264 gm. mol. in 1000 gm. water. The osmotic values of a series of cane sugar solutions determined in atmospheres by MORSE (**16**) and associates were plotted in a series of curves on which by interpolation the osmotic value of 0.264 gm. mol. weight-normal at 22° C. (the temperature at which the plasmolyzing solutions stood at the time of the determination) was found to be about 6.7 atmospheres. According to PFEFFER the corresponding value would be about 5.9 atmospheres.

Tests on *Spirogyra* showed that the cell contents were osmotically equal to a solution of NaCl containing about 0.16 gm. mol. in a liter of solution. In solutions of NaCl of this degree of dilution the difference between volume-normal and weight-normal is negligible in view of the wide range of error in the biological data. This may be seen by calculating weight-normality in accordance with the following formula given by RENNER (p. 500). When M equals the molecular weight of NaCl (58.5), m equals the number of gm. mol. per liter of solution, and s the specific gravity of the given solution, the corresponding weight-normality equals $\frac{1000m}{1000s-m.M}$. The specific gravity (20°/4° C.) of a 0.16 volume-normal NaCl (0.93 per cent) solution obtained by interpolation on a curve based on LANDOLT-BÖRNSTEIN-ROTH (**13,** p. 260) is about 1.005. Solving the equation, the corresponding value weight-normal is 0.1607 gm. mol. in 1000 gm. water.

The osmotic value of 0.16 gm. mol. NaCl in terms of atmospheres is not so readily deducible in this case as in that of cane sugar, and in view of the physical difficulties discussed by RENNER the writer has taken the corrected osmotic values given by him (p. 501) as a basis of calculation. By interpolation the osmotic pressure of 0.16 gm. mol. NaCl is about 7.2 atmospheres at room temperature. According to PFEFFER this corresponding value would be 5.7 atmospheres.

In this concentration the cell contents became markedly disordered after a short time, the chlorophyll band largely losing its spiral form. However, tests with solutions of cane sugar, slightly stronger osmotically, showed prompt and apparently normal plasmolysis. After 24 hours in this solution the chlorophyll band was still further disordered, although nearly all cells were clearly living and plasmolyzed normally in stronger concentrations.

Osmotic value of sea water

By the use of cane sugar solutions the osmotic pressure of *Spirogyra* here used was found to be about 6.7 atmospheres; the use of NaCl solutions gave about 7.2 atmospheres. Since the difference between these values is without doubt exceeded by the differences in the osmotic pressures prevailing in individual cells of the same filament, there is perhaps little point in discussing which of these values shall be adopted as the basis of further calculations. Hence, an approximate value of 7.0 atmospheres is adopted as the basis of further discussion.

The sea water used was dipped from outside the Fish Commission pier, where it is subject to almost unceasing tidal movement, and gave a density reading of about 1.0210 at 71° F. This was diluted with distilled water in various proportions and used as a plasmolyzing agent for *Spirogyra*. A stage similar to that just noted as indicating beginning plasmolysis was seen in a mixture containing *30 parts* by volume of sea water to *70 parts* of distilled water at 22° C. In this concentration *Spirogyra* and *Oedogonium* agreed in showing faint indications of incipient plasmolysis. *Mesocarpus* showed more distinct traces. These traces disappeared inside of 24 hours.

It appeared from these experiments that the osmotic presure of a 30 per cent sea water solution was approximately equal to about 7.0 atmospheres. By plain calculation the osmotic value of undiluted sea water would be about 23.3 atmospheres.

Since, however, it is well known that salts in aqueous solutions dissociate electrolytically in greater proportion in dilute solution than in greater concentrations, a given number of molecules might through their ionization be expected to cause a proportionally greater osmotic pressure at 30 per cent dilution than in a solution having three times that concentration. In order to get an idea of the general order of magnitude of the change here concerned, it is assumed that the behavior of the sea water approximates that of a half-normal NaCl solution. In this solution, corresponding to the undiluted sea water, about 73 per cent of the molecules would be dissociated at 18° C. (KOHLRAUSCH and HOLBORN, **12**), while a 30 per cent sea water solution corresponding roughly to N/6 concentration of NaCl would be dissociated about 81 per cent. This would increase the relative osmotic value from 173 to 181. This difference amounts to about 5 per cent of the osmotic value of the N/2 solution. To correct for this overestimate would require the subtraction of about 1.0 atmosphere from the first calculation. This would give an osmotic value of about 22.3 atmospheres for the sample of sea water here used.

In this connection it is of interest to compare this approximation with other determinations of this value. The salt content of the sample of sea water used may be calculated from the specific gravity reading 1.0210 at 71° F. This reading, reduced to a basis of specific gravity $\frac{15°\text{C.}}{4°\text{ C.}}$ by means of LIBBEY'S (**14**) table, becomes 1.0216. This value reduced to terms of salt content by the use of PETTERSON'S (**17**) comparison of specific gravity with results obtained by titration of Cl content indicates a total salt content of about 2.93 per cent.[2] Assuming this result to have been approximately correct, it is possible by use of the "Challenger" (**7**) analyses to ascertain

[2] A discussion of the methods of calculating specific gravity and salt content with a diagram for the ready handling of these data is found in Science N.S. **42**:732–735. 1915.

the quantity of principal salts present, and by means of their osmotic equivalents to calculate roughly the osmotic value of the sample of sea water used in this work.

PFEFFER has calculated the osmotic equivalents of solutions of the common salts, giving the atmospheres of pressure exerted by 1 per cent solutions made up on the basis of 1 gm. of salt in 100 ccm. of solution. The recalculation of the osmotic value of NaCl by RENNER already referred to has given a considerably increased value for this salt. There has been no similar recalculation for the other sea salts known to the writer, but since the quantities of salts other than NaCl are small, but a relatively small effect would result from their correction. $MgCl_2$, present in second largest quantity, namely, 0.32 per cent in the sample of water here concerned, was recalculated by the writer in a very approximate way from freezing point values given in LANDOLT-BÖRNSTEIN-ROTH'S (13) tables for the temperature of 22° C., and a value somewhat greater than that given by PFEFFER was obtained. The values here discussed are brought together for convenient reference in table I. A glance at

TABLE I

Salts	"Challenger" proportions	Quantity in sample used	Atmos. press. 1 per cent sol. by vol. Pfeffer	Osmotic values Pfeffer	Osmotic values recalculated
$NaCl$....	$0.777 \times 2.93 = 2.28$ per cent		$\times 6.09$ atmos.	$= 13.8$ atmos.	17.30 atmos.
$MgCl_2$....	$0.109 \times 2.93 = 0.32$		$\times 4.98$	$= 1.6$	2.16
$MgSO_4$....	$0.048 \times 2.93 = 0.14$		$\times 1.93$	$= 0.3$	0.30
$CaSO_4$....	$0.036 \times 2.93 = 0.10$		$\times 2.00(?)$	$= 0.2$	0.20
K_2SO_4....	$0.025 \times 2.93 = 0.07$		$\times 2.72$	$= 0.2$	0.20
	0.995	2.90 per cent	equals	16.1 atmos.	20.16 atmos.

this table shows that if PFEFFER'S osmotic values are accepted, the osmotic pressure of sea water falls short of that contained in the experiment described by a ratio of 16.1 to 22.3. On recalculating, the total pressure derived from analytical data exceeds 20 atmospheres.

In this connection it is of interest to compare with these values those obtained by GARREY (10), using the freezing point method. As a result of several freezings, he concluded that for the water of the basin of the United States Fish Commission the average lower-

ing of the freezing point was −1.82° C., corresponding to an estimated osmotic value of about 22 atmospheres at 0° C. (about 23.7 atmospheres at 22° C.). Assuming the osmotic value of a 1 per cent NaCl solution at 22° C. to be 7.6 atmospheres, in accordance with RENNER'S recalculation (p. 501), GARREY'S result would call for a salt content equal to about 3.1 per cent NaCl. According to SUMNER, OSBURN, and COLE (**22**), the water of Buzzard's Bay and Vineyard Sound varies in salt content between 2.84 and 3.29 per cent total salt.

Osmotic pressure of marine algae

An attempt was made to determine the osmotic pressure existing in certain of the commoner bright green forms found abundantly in the neighborhood of Woods Hole.

Cladophora gracilis var. was found growing on rocks below low tide level near the wall in front of the residence building of the United States Fish Commission. This alga grew in a position where the water was constantly changing and where it was not subject to any marked temperature variation.

Enteromorpha intestinalis, according to DAVIS (**6**), is a type belonging characteristically to the region between tide levels, where it occurs attached to stones, shells, and woodwork. At low tide, therefore, it is often subject to a considerable concentration of its cell contents through evaporation.

Chaetomorpha Linum, like *Cladophora*, is not subject to such wide variations, being found characteristically below the low tide mark.

Small tufts of the filaments or pieces of the frond were placed in graduated series of solutions of cane sugar and NaCl and examined with reference to their osmotic behavior.

In the cane sugar solutions *Cladophora* first showed traces of plasmolysis in 0.85 to 0.90 gm. mol. per liter of solution, corresponding to 1.04 and 1.13 gm. mol. in 1000 gm. of water, corresponding to about 28 and 30.7 atmospheres of pressure respectively.

Enteromorpha gave similar results in solutions containing between 0.80 and 0.90 gm. mol. volume-normal, corresponding to about 0.96 and 1.13 gm. mol. weight-normal, representing 25.8 to

30.7 atmospheres, respectively. *Chaetomorpha* required a 0.9 volume-normal concentration (1.13 weight-normal), corresponding to 30.7 atmospheres, to produce the same effect.

In NaCl solutions corresponding results were seen in *Cladophora* in 0.75 to 0.80 gm. mol. volume-normal. RENNER (p. 501) has pointed out that in NaCl the osmotic pressure is proportional to the molar concentration calculated on the liter of solution, 0.1 gm. mol. having an osmotic pressure of 4.5 atmospheres at 18° C. Hence these concentrations correspond approximately to a range between 33.7 and 36 atmospheres. *Chaetomorpha* showed first traces of plasmolysis in 0.70–0.80 gm. mol., corresponding to 31.5–36 atmospheres of pressure.

The reason why an osmotically greater concentration was required in the case of the NaCl solution to give the same result as that seen in the osmotically less concentrated sugar solution is probably to be found in the greater facility with which these algae admit NaCl. It is probable that the surplus atmospheres required in the NaCl solution over the sugar solution roughly mark the greater degree of penetration of the former. The work of JANSE (**11**) and of DREVS (**8**) is significant in this connection.

In 1900 and 1901 DUGGAR (**9**) carried out similar plasmolytic studies on marine algae at Naples and at Woods Hole. The results presented in his paper seem to have been obtained at Naples, since the values are referred to Naples water. Experiments on *Chaetomorpha Linum* made with solutions of osmotic agents in distilled water, as would be expected, showed markedly higher osmotic pressures than the writer found at Woods Hole. At Naples *Chaetomorpha* was found to be isosmotic with 1.26 gm. mol. by volume cane sugar or 1.73 gm. mol. by weight, having an osmotic pressure of about 34.7 atmospheres; with 0.93 gm. mol. of NaCl by volume equal to about 41.8 atmospheres; and with 1.40 gm. mol. by volume of KNO_3. The freezing point of Mediterranean water was found by BOTTAZZI (**4**) to be $\Delta = -2.29°$ C., corresponding to about 27.6 atmospheres at 0° C., or about 30 atmospheres at 22° C. This is the equivalent of nearly 1 per cent NaCl, or 6.2 atmospheres higher than values obtained at Woods Hole by GARREY. Analyses of Mediterranean water from Naples reported by ROTH (**21**) gave

a total salt content of about 3.85 per cent, a value which agrees very well with these findings.

In 1901 REED (**19**) made a series of plasmolytic determinations with marine algae at Woods Hole and in solutions made up with distilled water found the following osmotic values: *Cladophora* (sp. not given): NaCl isosmotic with 0.7 gm. mol. NaCl by volume, roughly equal to 31.5 atmospheres at 18° C.; cane sugar isosmotic with 0.8 gm. mol. by volume (0.965 gm. mol. by weight), equal to 25 atmospheres of pressure at 18° C. *Chaetomorpha* (sp. not given): NaCl isosmotic with 0.9 gm. mol. by volume, equal to about 40.5 atmospheres at 18° C.; cane sugar isosmotic with 0.9 gm. mol. by volume (1.11 gm. mol. by weight), equal to about 29.5 atmospheres at 18° C.

Osmotic surplus in marine algae

In order to ascertain the turgor pressure of the marine algae, a comparison between the osmotic value of the cells and that of the sea water itself is necessary. To facilitate such a comparison these values are brought together in table II. For such a calculation as

TABLE II

OSMOTIC PRESSURES OF ALGAE AT WOODS HOLE

ALGAE	CELL CONTENTS ISOSMOTIC WITH				SEA WATER PER CENT BY VOLUME
	Cane sugar gm. mol. in liter of solution		Sodium chloride gm. mol. in liter of solution		
	gm. mol.	atmos.	gm. mol.	atmos.	
Spirogyra elongata	0.25	6.7	0.16	7.2	30 Osmotic pressure of sea water corrected = 22.3 atmos.
Cladophora gracilis	0.85 0.90	28.0 30.7	0.75 0.80	33.7 36.0	
Enteromorpha intestinalis	0.80 0.90	25.8 30.7	.....	.....	
Chaetomorpha Linum	0.9	30.7	0.70 0.80	31.5 36.0	

that here required it is important to adopt a correct osmotic value for sea water. For purposes of this paper 22.3 atmospheres, corresponding to a sea water concentration of 2.93 per cent total salt, is adopted. A glance at the daily density readings made by the United States Fish Commission shows a considerable variation in the salt content of Woods Hole water from time to time, a fact that

should be borne in mind in comparing the results of different observers. It seems from the observations of SUMNER (**22**, p. 53) and his associates that the salt content at Woods Hole is known to vary between 2.84 and 3.29 per cent total salts.

The osmotic surplus found in the algae studied is easily calculated by subtracting 22.6 atmospheres from the observed osmotic pressures. The results of such a calculation appear in table III.

TABLE III

OSMOTIC SURPLUS IN MARINE ALGAE AT WOODS HOLE

ALGAE	OSMOTIC SURPLUS DETERMINED WITH	
	Cane sugar	Sodium chloride
Cladophora gracilis	5.4 atmospheres 8.1	11.1 atmospheres 13.4
Enteromorpha intestinalis	3.2 8.1	....
Chaetomorpha Linum	8.1	8.9 13.4
Average values	6.6 atmospheres	11.7 atmospheres

The strikingly higher values obtained with NaCl are probably due to the penetration of this substance with the consequently higher concentration required to produce traces of plasmolysis. The writer, therefore, is inclined to regard the lower reading obtained with cane sugar as more nearly the true value in this case. It should be borne in mind, however, as COPELAND (**5**) has shown, that this osmotic surplus is subject to influence from external conditions through their effect on nutrition and in other ways.

Summary

1. By means of the plasmolytic method it is shown that the osmotic pressure in the cells of *Spirogyra*, *Zygnema*, and *Oedogonium* found in Nobska Pond, near Woods Hole, Massachusetts, at 22° C., is equal (1) to about 0.25 gm. mol. in a liter of solution of cane sugar, corresponding to 6.7 atmospheres, (2) to about 0.16 gm. mol. NaCl per liter of solution, corresponding to 7.2 atmospheres, and to a 30 per cent sea water solution (sea water = 2.93 per cent total salts).

2. The osmotic value of the sea water sample calculated from plasmolytic experiments was found to be about 22.6 atmospheres. This value determined by the freezing point method by GARREY reduced to 22° C. was 23.8 atmospheres.

3. The osmotic surplus of *Cladophora gracilis*, *Enteromorpha intestinalis*, and *Chaetomorpha Linum* was found to be about 6.6 atmospheres when determined by means of cane sugar, and 11.7 atmospheres for *Cladophora* and *Chaetomorpha* when determined by means of NaCl. The penetration of NaCl is supposed to be largely responsible for the higher value obtained with this salt.

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INDEPENDENT EVOLUTION OF VESSELS IN GNETALES AND ANGIOSPERMS

W. P. THOMPSON

(WITH ELEVEN FIGURES)

The possession of vessels by both angiosperms and Gnetales is perhaps the strongest argument, both of those botanists who believe that the angiosperms have been derived from Gnetales, and of those who maintain that the two groups have descended from a common ancestor. It has therefore received much emphasis in all discussions of the origin of angiosperms and of the affinities of the Gnetales. The emphasis which it has received, however, is out of all proportion to the actual study of the vessels themselves.

In a systematic study of the anatomy of the Gnetales (**4**) which the writer is carrying on, overwhelming evidence has accumulated that, although the completed vessels of the two groups bear a remarkable resemblance to each other, nevertheless their mode of development and their actual origin have been quite distinct in the two groups. In other words, we have in the case of these vessels another of the baffling examples of parallel development.

Evolution of Gnetalean vessel

The typical vessel of *Ephedra*, the most primitive of the Gnetales, is characterized by the occurrence on its end wall of several or many large bordered pits which lack the middle lamella and in which the bordering area is narrow. The end of such a vessel is shown in radial section in fig. 1 and in tangential section in fig. 2. The figures show that this type of vessel differs from the familiar angiospermic type in having several small bordered perforations in place of the single large one of the higher type. BOODLE and WORSDELL (**1**), and the writer (**4**), have shown how this *Ephedra* type of vessel has been evolved from the ordinary tracheid of the coniferous type. The changes involve (1) the enlargement of the whole element, (2) the enlargement of several of the bordered pits

on the oblique end wall, (3) the reduction in the border of these pits, and (4) the disappearance of the tori and middle lamellae. In conservative regions of *Ephedra*[1] all stages in these processes may be found; in other words, there are all gradations between tracheids and vessels. Fig. 3 represents the radial view of the end of a vessel from the young wood of *Ephedra monostachya*. At the very end are typical bordered pits and higher up are seen stages in their transformation into perforations of the ordinary *Ephedra* kind. Such a gradual transformation is not often seen, but various intermediate conditions between bordered pits and perforations are common in conservative regions. Fig. 4 represents a tangential view of a similar end wall and shows clearly the relationship between perforations and bordered pits. For further details of the process the reader is referred to the previous article by the writer (4).

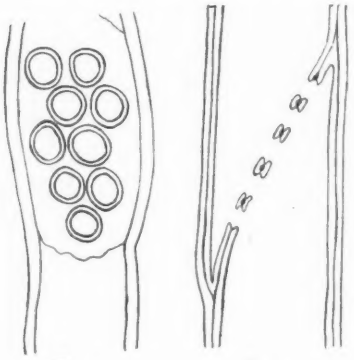

FIG. 1 FIG. 2

FIGS. 1, 2.—Typical vessels from *Ephedra monostachya:* fig. 1, radial; fig. 2, tangential section; all figs. ×250.

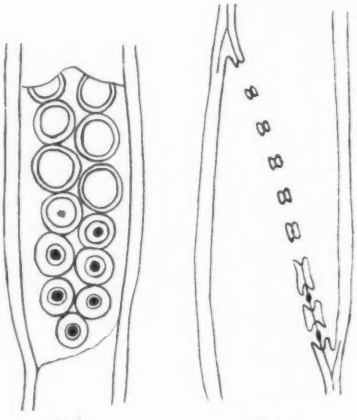

FIG. 3 FIG. 4

FIGS. 3, 4.—Vessels from *Ephedra monostachya*, showing relationship between perforations and bordered pits.

The typical vessel of *Gnetum*, the highest of the Gnetales, differs from that of *Ephedra* in having a single large oval or elliptical perforation instead of several circular ones (fig. 5). It is, in other words, like the highest angiospermic type except that as a rule it exhibits a narrow border. Even this

[1] Young stem and root, node, seedling, etc.

border may disappear, however, in the old wood of large trees. In spite of the great differences between the typical vessels of *Gnetum* and those of *Ephedra*, a comparative study of the conservative regions of many species of the former has shown that the *Gnetum* type undoubtedly has been derived from the *Ephedra* type and has revealed the course of its evolution.

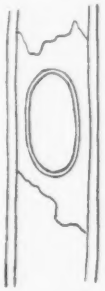

FIG. 5.—Typical vessel of *Gnetum*.

In such regions of *Gnetum* the *Ephedra* type of vessel is of common occurrence, as has been noted by DUTHIE (**2**) and the writer (**5**). Such a vessel from the young root of a seedling of *G. Gnemon* is shown in fig. 6. Another vessel is shown in tangential view in fig. 7. In this vessel even the relationship to bordered pits is shown. While *Gnetum* naturally does not show the transitions to tracheids as well as *Ephedra*, nevertheless intermediate conditions may easily be found. In some species of *Gnetum* the type of vessel characteristic of *Ephedra* is much more common than in others, and within the same species it is more common in certain conservative regions and certain individual specimens than in others.

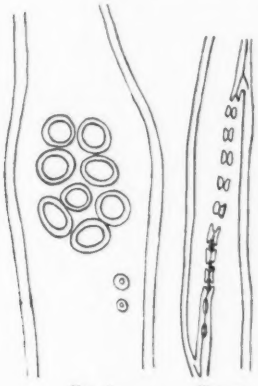

FIG. 6 FIG. 7

FIGS. 6, 7.—Fig. 6, vessel from root of seedling of *Gnetum Gnemon:* note that it is of the type characteristic of *Ephedra;* fig. 7, tangential section of vessel similar to that shown in fig. 6.

The way in which the *Gnetum* type of vessel has been evolved from the *Ephedra* type is easily observed in such regions and is illustrated in fig. 8. The changes involve the further enlargement of the individual perforations and the disappearance of the portions of the wall between them. In this way the several perforations fuse in a single large one. In fig. 8*a* three of the perforations near the top have fused into a common opening, although parts of their original outlines are still distinct. Near the bottom two pits have fused in similar fashion. At two points (one near the top and the other near the middle) it may be observed that

the pits have fused on the side of one element but not on the side of the other. In fig. 8*c* all have fused in a common perforation on one side but only in groups on the other. In fig. 8*d* the process is nearly completed, the indications of the individual perforations being visible only along the left side. In different vessels all sorts of conditions with respect to the fusion of perforations may be observed. In some cases they first fuse horizontally and in some cases vertically.

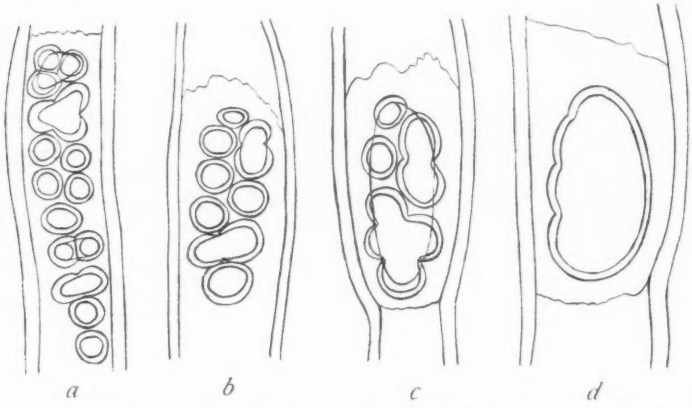

FIG. 8.—Series of vessels from node of seedling of *Gnetum moluccense*, illustrating transitional stages between *Ephedra* type and *Gnetum* type of vessel.

Evolution of the angiospermic vessel

If there is any genetic relationship between the Gnetalean and angiospermic vessels, we should find in the primitive types of the latter a course of development similar to that just outlined, or at least some vestiges of the Gnetalean condition.

The primitive type of angiospermic vessel is undoubtedly the so-called scalariform kind (illustrated in fig. 9 from the wood of *Betula lutea*). The most advanced type is the familiar porous kind with a single large perforation (fig. 10). In the scalariform type the perforation of the end wall is crossed by a large number of parallel horizontal bars, or, in other words, there are many horizontally elongated perforations. The outline of the whole perforated area is similar in shape and size to the single perforation of

the higher type. It is not my intention to discuss the origin of this scalariform vessel in detail. It may be pointed out, however, that such an end wall may have developed in one of two ways.

(1) The scalariform perforations may be modifications of the scalariform bordered pits characteristic of the primary tracheids of all vascular plants and of the secondary tracheids of many ancient forms (*Lepidodendron*, *Calamites*, Bennettitales, etc). If this alternative is the correct one, we have in the angiospermic vessel of this type a retention of a very primitive form of pitting which has disappeared from the secondary tracheids of all plants above the cycads with the possible exception of such plants as *Trochodendron*, *Tetracentron*, etc. (6). With the exception of these perforations it is also absent from the vessels of all angiosperms, although JEFFREY and COLE (3) regard as vestiges of vessels certain elements with this kind of pitting which they have found in wounded *Drimys* and which occur normally in *Trochodendron* and *Tetracentron*. According to one alternative, therefore, the angiospermic vessel has been produced when the scalariform bordered pits on the end wall of a tracheid lost their membranes and became perforations. At the same time the pits of the lateral walls were transformed into the familiar crowded circular type.

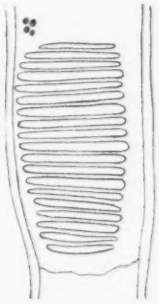

FIG. 9.—Scalariform vessel of birch.

FIG. 10.—Typical angiospermic vessel from *Vaccinium corymbosum*.

(2) On the other hand, the scalariform perforations may have resulted from the fusion of pits of the ordinary circular multiseriate type. In many angiospermic woods all gradations may be observed between scalariform and multiseriate circular pitting. If this alternative is correct, the angiospermic vessel has not been derived from the primitive tracheid with scalariform pits, but from the higher ordinary type of tracheids with circular bordered pits. The perforations are therefore not retentions but new productions. It

should be pointed out that on the basis of the first alternative the transitions between multiseriate and scalariform pitting are to be interpreted in the reverse direction, the multiseriate pits having been derived from the scalariform.

But, no matter which of these two views is the correct one, it is plain that the vessel with the scalariform end wall is the primitive kind in angiosperms. One evidence that this is true is the fact that it prevails in those angiosperms which are admittedly primitive, whereas the type with the single large perforation prevails in the higher forms. Sometimes the two types are found in different members of the same family, but in such cases the more primitive members of the family are characterized by the possession of the scalariform type, while the higher members have the singly perforated type.

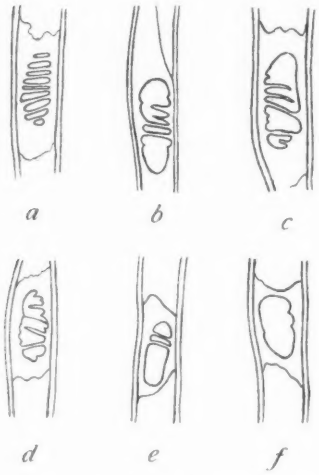

FIG. 11.—Series of vessels from wood of *Vaccinium corymbosum*, illustrating transformation of scalariform perforations into single large perforation.

That the scalariform type of vessel is the primitive one is further shown by cases of actual transformation of this kind into the kind with the single perforation. Not only do these cases prove the primitiveness of the former, but they also give us a picture of the evolution of the single perforation.

Some years ago the writer discovered in the wood of *Vaccinium* all transitions between the scalariform perforations and the single large perforation. The process consists simply of the gradual loss of the bars. Some stages are represented in fig. 11. A typical scalariform vessel is shown in *a;* in *b* two bars remain intact, two more are incomplete, and the positions of others are indicated by the projections from the sides. Random samples further illustrating the process are represented in *c* and *d*. In *f* the process is nearly

completed, the positions of three bars being indicated by projections. In the wood of different species of *Vaccinium* innumerable conditions similar to these may be found side by side. I have been careful to determine that none of these cases are due to imperfect sectioning, but that they represent the actual state of affairs. This has been done by means of careful series of sections in celloidin. Moreover, views like *e*, which are common, could not be produced by the carrying away of the bars in sectioning, for in that case the margin of the perforation would not be smooth, but would show where the bars had been broken. From these facts it is clear that the angiospermic vessel with the single large perforation has been derived from that with the scalariform perforations.

Comparison of evolution of Gnetalean with that of angiospermic vessels

We have seen that the single large perforation of the Gnetalean vessel has been produced by the fusion of several perforations derived from circular bordered pits. We have also seen that the similar single large perforation of the angiospermic vessel has been evolved from the scalariform type. Evidently, therefore, the two are not genetically related. In the evolution of the Gnetalean vessel there is and can be no scalariform stage. The Gnetalean vessel usually has only two rows of circular pits and never more than three. Consequently, no matter how the fusions take place, no scalariform bars can result. The Gnetalean and angiospermic vessels may or may not have been derived from the same type of element, but from the very beginning the evolution of the two has taken place along entirely different lines. In the Gnetalean line a few circular bordered pits, haphazardly arranged, have enlarged and fused in a single perforation; in the angiospermic line long narrow parallel slits, which have been retained or evolved, have fused to form a similar single perforation.

Conclusions

From these considerations it follows that the vessel of *Gnetum* should disappear from all discussions of the origin of angiosperms. The possession of vessels by the two groups can no longer be used

as a demonstration or even as evidence of genetic connection between them; it is rather to be used as a remarkable illustration of development by different plants of the same highly specialized structure. It is to be compared with the independent evolution in lycopods, horsetails, and ferns of similar seedlike structures. To what extent this applies to other points of resemblance between Gnetales and angiosperms is reserved for future discussion.

Summary

1. The vessel of *Gnetum* with the single large perforation in its end wall has been evolved by the enlargement and fusion of several haphazardly arranged bordered pits.

2. The vessel of angiosperms with the similar single large perforation has been evolved from the type with many long, narrow, scalariform perforations.

3. On account of the entirely different courses of evolution by which they were produced, there can be no genetic connection between the vessels of the two groups. They furnish a remarkable illustration of independent development of similar structures.

4. The possession of vessels by both angiosperms and Gnetales cannot be used as an argument in favor of the derivation of angiosperms from Gnetales or of both from common ancestors.

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A COLUMELLA IN MARCHANTIA POLYMORPHA

J. E. CRIBBS

(WITH PLATES I, II)

Introduction

Marchantia polymorpha, because of its wide distribution and common occurrence, has long been used as a representative of the Marchantiaceae for laboratory study. The large number of sporophytes appearing upon a single receptacle gives excellent opportunity to obtain various stages of development without much difficulty. Notwithstanding the wide usage of this species and the abundant literature dealing with the development and anatomy of the Marchantiaceae, it appears that in the organization of the capsule the tendency to develop a columella has never been recorded.

In the work of LEITGEB,[1] KIENITZ-GERLOFF,[2] and others observations are given on the development of the elaters within the capsule; and in each case these have been found to be irregularly disposed, appearing as elongated cells which are at first quite indistinguishable from the sporogenous cells, but soon may be detected by their failure to develop transverse walls. The present paper is concerned with some unusual incidents which may occur in the organization and development of these sterile tissues.

The material from which these observations were made was collected during the first week of September 1914. It was taken from an exposed area which had been cleared during the previous fall and burned over. As is frequently the case in such instances, it developed here in dense formation during the following summer. My attention was first attracted to the appearance of columnar structures during the spring of 1915 while preparing material from this collection. Further study of a large quantity from this locality gave one additional instance of this type of organization.

[1] LEITGEB, HUBERT, Untersuchungen über die Lebermoose. Vol. 6. 1881.

[2] KIENITZ-GERLOFF, F., Vergleichende Untersuchungen über die Entwickelungsgeschichte des Lebermoossporogons. Bot. Zeit. **32**:161. 1874; **33**:777–782. 1875.

Because of the dryness of the season and the infringement of more advanced stages of vegetation it was impossible to secure additional material from this locality during the fall of 1916.

Investigation

Two stages were observed in the organization of a central column of sterile tissue within the capsule. Fig. 1 gives a conception of the extent of development in the simpler of these. It may be seen that the close assemblage of a large number of elaters in the center has resulted in almost complete sterilization there. It will be observed in this case, too, that the central column was not originally composed entirely of cells which developed elaters, but mixed with these were sporogenous cells which disorganized before they could form tetrads, leaving protoplasmic remains which take stains deeply. It is doubtful whether the disintegration of these is to be interpreted as a source of additional nutriment for those which remain, or is in any way to be associated with this behavior which is characteristic of members of the Jungermanniales. It seems rather to be an occurrence associated with the unusual, close development of sterile tissue, for it may be observed that immediately outside of this zone there is no such behavior. The capsule, in this instance, has developed to the point where the spores have become isolated from the tetrads, and the elaters are beginning to develop the spiral thickenings characteristic of their walls. These are laid down beneath the more or less spirally disposed protoplasm which is conspicuous at this stage. This columnar development is not the result of assembling the normal number of elaters into a central position, for the diffuse arrangement so characteristic of the species is still maintained in the rest of the capsule; nor is the number, excluding those in the central column, in any way reduced from the normal average.

In the second stage of development (figs. 2, 3) there has been a complete elimination of sporogenous cells, so that the columella is composed of sterile tissue only. The sporophyte in this case was less mature than that represented in fig. 1. The scattered elaters show an almost evenly distributed protoplasmic content which has not yet collected preliminary to the formation of the spiral thicken-

ing. The sporogenous cells are in the compact spore stage following the development of tetrads.

The columella, which at this stage is clearly defined, extends from the base of the capsule through more than three-fourths of its length. It is composed largely of elaters which diverge slightly at the free end. Intermingled with the elaters occur tissues developed from sporogenous cells which have elongated and divided transversely a number of times, but failed to reach the spore mother cell stage; thus remaining as elongated sterile chains of cells which will not develop into elaters, but may, as in fig. 1, completely disintegrate during the later history of the capsule, or in this more compact columella there may be but a partial disorganization. This type of structure, judging from its position and development, is suggestive of the elaterophore of *Pellia*. It has a less advanced state of organization, however, since there is no apparent tendency either to diminish the number of diffusely scattered elaters or to assemble them at the apex of the column.

Another phase in the development of sterile tissue within the capsule is met with in the group of cells which occur at the apex. The development of sterile cells at this point at once recalls the condition existing in *Aneura*. KIENITZ-GERLOFF refers to the development of two layers of sterile cells here. Examination of a large number of sporophytes, however, will show that there is considerable variation in the amount of this tissue, and also that it may be formed in different ways.

Fig. 4 represents a young sporophyte when the greater density of the protoplasm in the distal half is just becoming manifest. There has been no separation of sterile tissue at the apex up to this stage. In this instance two eggs have been developed in the venter, only one of which is seen to be developing an embryo. It would seem, from the fact that all the other eggs developed on this receptacle were fertilized and forming sporophytes, that the failure of this one to do so may be attributed to a potential sterilization which follows the initial development of the egg first fertilized, a response comparable perhaps to that of *Pellia* or *Pallavicinia*, where but one sporophyte regularly develops from a group of closely assembled archegonia.

When the sporophyte has attained the stage immediately preceding the invasion of the gametophytic tissue by the developing foot, the first isolation of cells which will contribute definitely to the apical group may sometimes be observed (fig. 5). The first isolation is suggested by the appearance of more pronounced cell walls. In the structure of the cells themselves at this stage there is usually no observable difference; but when once the foot establishes itself, and the sporogenous cells rapidly increase in density and begin elongation, these become more prominent because of their less density, their more conspicuous nuclei, and their failure to undergo elongation.

In most cases a single layer of cells is formed, cut off at this early stage, although occasionally two layers in addition to the wall cells will be found. These originally isolated cells are commonly carried forward at the apex as the sporogenous cells below them continue their elongation; and they generally compose all there is of sterile tissue here, but not uncommonly the amount is increased in one of two ways. The sporogenous initials may by periclinal divisions contribute to the mass just before the rapid series of anticlinal divisions which accompanies the broadening of the capsule and elongation of the sporogenous cells (fig. 7). Moreover, the bulk of sterile tissue may be increased by the division of wall cells near the apex (fig. 6). The contribution by this method is apparently very slight and less common than by the former. A third method by which the tissue may be increased in bulk would be by continued division of the sterile cells after their first isolation. Although this would seem a very probable occurrence, I was unable to observe any direct evidence of it. The apical end of a more mature sporophyte is shown in fig. 8. The sporogenous cells are in the tetrad condition, and the close association of the elaters with the sterile cap toward which they converge is very conspicuous.

Conclusions

In the Marchantiaceae, the first family of the Bryophytes in which there occurs any sterilization of potentially sporogenous tissues, the elaters are commonly diffusely arranged; but in

Marchantia they sometimes develop so abundantly in the center of the capsule as to produce a columella.

Intermingled with the elaters occurs considerable tissue derived from sporogenous cells which undergo elongation and divide frequently, giving rise to chains of cells. These fail to reach the spore mother cell stage, and may persist for a considerable time. They either partially or completely disorganize, however, about the time the elaters develop their wall thickenings.

The disintegration of these sporogenous cells is a feature limited to the columella, and apparently is not essentially a nutritive function, but is a condition arising from the close grouping of the central elaters.

A columella of this type strongly suggests the elaterophore of *Pellia*, and is an advancement in the organization of the sterile tissues of this family along the same line of development that regularly appears in members of the Anacrogynae.

That this unusual occurrence may be attributable directly to external factors is highly improbable; but should be considered the first stage in the tendency to break up the sporogenous mass, a feature very prominently displayed in the sporophyte as it increases in size and complexity.

The initial separation of sterile cells at the apex may occur even before the intrusion of the proximal part to form the foot, or it may first be recognized at the time of the initial elongation of the sporogenous cells.

The group of cells thus separated at the tip may be added to either by the division of the wall cells, or by periclinal walls in the elongating sporogenous cells.

This occurrence of a cap of sterile cells at the apex of the capsule is likewise a feature appearing prominently in members of the Anacrogynae, where in *Aneura* it bears attached elaters. The occasional appearance of three or four layers of sterile cells at the tip, and the convergence of the elaters, together with the close relation they frequently bear to this point, are further evidences of transitional features from the diffuse arrangement of elaters to a definite organized structure such as the elaterophore found in members of the Jungermanniales.

I wish to express my appreciation of the helpful criticism of Dr. W. J. G. LAND.

UNIVERSITY OF CHICAGO

EXPLANATION OF PLATES

Fig. 3, ×63; all others, ×450

FIG. 1.—Simple columella at time of separation of spores from tetrads, showing dense cluster of elaters and disorganized sporogenous tissue.

FIG. 2.—Columella immediately preceding thickening of elaters; composed largely of chains of sporogenous cells which failed to reach spore mother cell stage.

FIG. 3.—Median view of sporophyte giving topography.

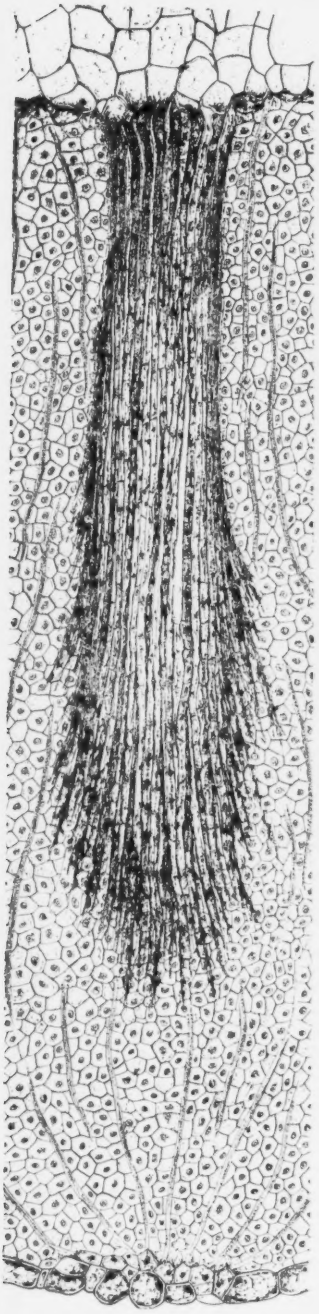
FIG. 4.—Young sporophyte preceding isolation of sterile cap cells; unfertilized egg beside sporophyte.

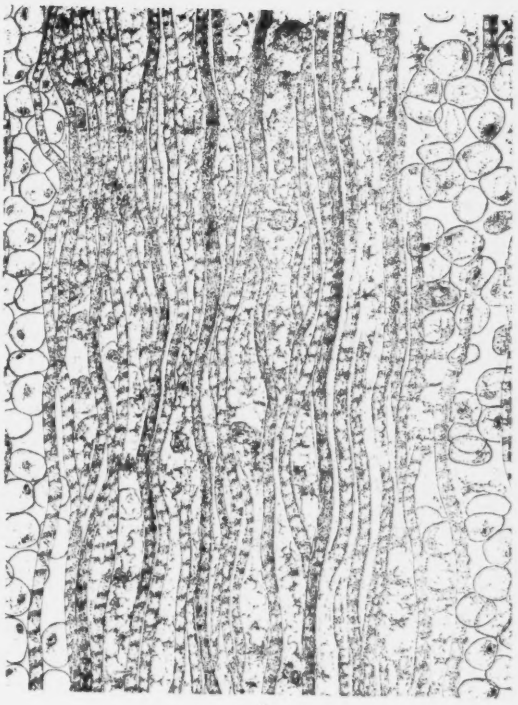
FIG. 5.—First isolation of sterile cap cells preceding elongation of sporogenous cells.

FIG. 6.—Cap cells readily distinguished at time of invasion of foot; wall cells contributing to sterile cap group.

FIG. 7.—Unusually large mass of sterile cells, 4 deep at apex.

FIG. 8.—Close relation of radiating elaters to apical group, tetrad stage.





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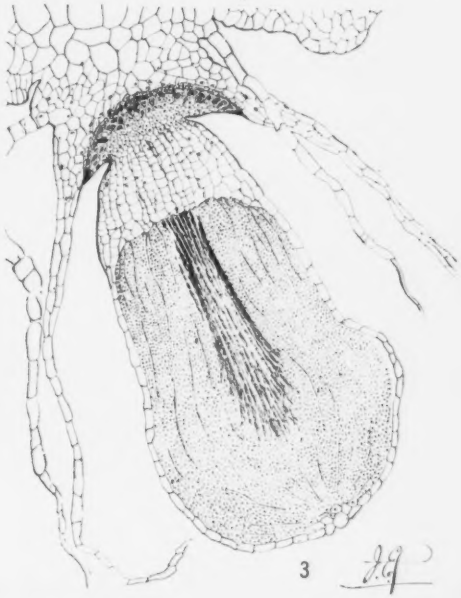

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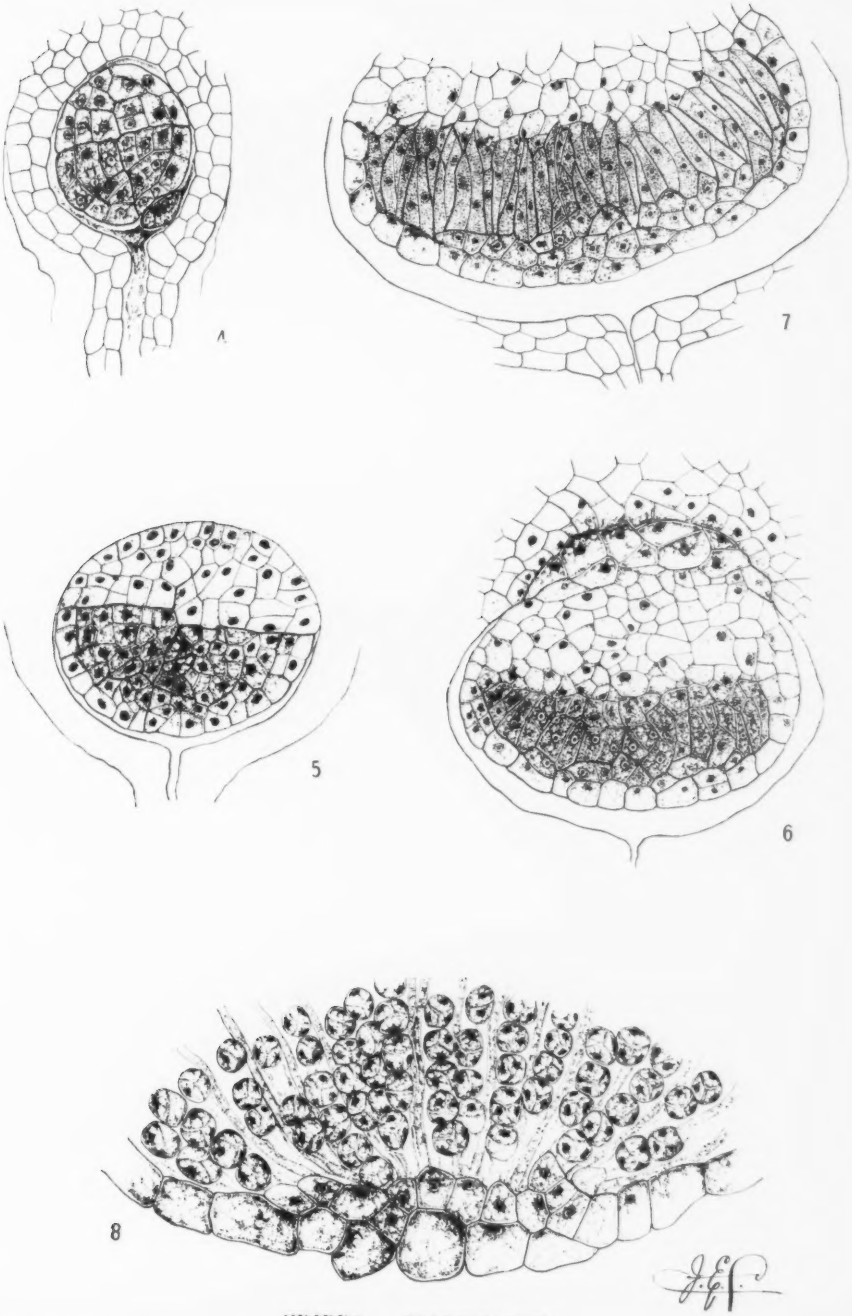

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APOGAMY IN THE CYATHEACEAE

ALMA G. STOKEY

(WITH TEN FIGURES)

Since the discovery of apogamy in *Pteris cretica* by FARLOW (3) in 1874, it has been observed in about 15 genera and 30 species of the Polypodiaceae. There are records of its occurrence in 3 other families of the Filicales, namely, the Osmundaceae, the Hymenophyllaceae, and the Marsiliaceae. It has been reported by SADEBECK (9) in *Todea africana*, by LEITGEB (7) in *Osmunda regalis*, by STANGE (12) in *Todea rivularis* and *T. pellucida*, by BOWER (1) in *Trichomanes alatum*, by WORONIN (14) in *Trichomanes Krausii*, and by SHAW (11) and STRASBURGER (13) in *Marsilia*.

For several years I have been making a study of the prothallia of the Cyatheaceae, most of the results of which will appear in a later paper. I have had under cultivation 13 species belonging to 5 of the 7 genera. The species studied include 6 species of *Alsophila*, 1 of *Hemitelia*, 2 of *Cyathea*, 2 of *Dicksonia*, and 2 of *Cibotium*. I am indebted to Dr. J. M. GREENMAN for the determination of all the species with the exception of *Alsophila Cooperi* F. Muell., which was obtained from the greenhouses of Harvard University, and *Cyathea muricata* Wild. (*Alsophila muricata* Desv.), obtained from the New York Botanical Garden.

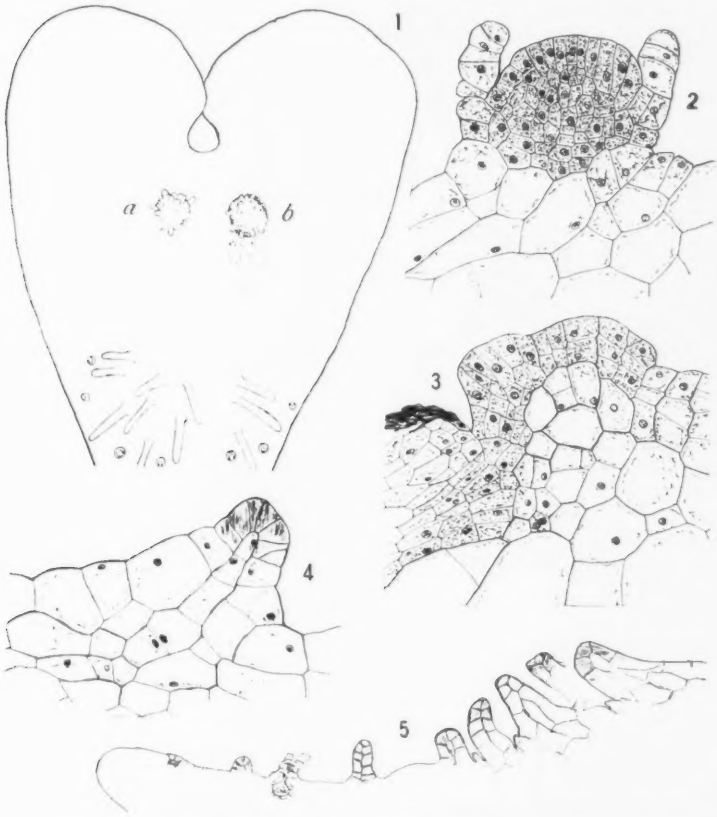
In order to obtain pure cultures it was found necessary to take measures to remove foreign spores from material obtained from greenhouses where other ferns were growing. The leaves, which were collected before the sporangia had begun to open, were washed in running water and brushed rather vigorously while in the water. They were dried on sterilized glass plates and the spores which were collected were sowed on various culture media. Cultures from material handled in this way contain few if any foreign prothallia. It is not difficult to tell by the appearance of a culture whether or not there are any foreign prothallia present, owing to differences in the rate of development and in the general habit of the prothallia of different species. It is fairly easy to distinguish between the

prothallia of the Polypodiaceae and the Cyatheaceae because of the differences in the antheridia and in the types of hairs.

From 2 to 15 cultures were made of all the species studied, the cultures running from 5 to 15 months. Various media were used: several different mixtures of soil; black peat, with and without Knop's solution; and porous clay crock standing in Knop's solution. Some of the cultures were raised in a laboratory where they received no direct sunlight except late in the afternoon; others were raised in a greenhouse where they received sunlight except for a few hours at midday.

The few cases of apogamy found occurred in the genera *Dicksonia* and *Cyathea*. They were found in cultures on peat raised in the greenhouse in the winter of 1915–1916. I am indebted to Professor A. VINCENT OSMUN of the Massachusetts Agricultural College for data on the weather of that winter and the 5 years preceding. While the total number of hours of sunlight for the winter of 1915–1916 was a little below the average, the number of days in which there was snow on the ground was considerably above the average, so that the greenhouse cultures of that winter probably received more light than any other set of cultures. LANG (**8**) regards intense light and probably high temperature as important factors in the development of apogamous structures. SCHLUMBERGER (**10**) found that in the case of *Woodsia ilvensis* the production of the cylindrical process was caused by such unfavorable conditions as weak light and dryness. HEILBRON (**4**) did not find dryness to be a factor and suggests that summer cultures are more likely to become apogamous than winter cultures, but his experiments with different qualities and intensities of light in moist cultures at a high temperature gave negative results. Mme. WORONIN is inclined to regard dryness as the cause of apogamy in the forms which she studied, as in these cases it cannot be attributed to intense light. This explanation is criticized by ISABURO-NAGAI (**6**), who found that in the case of *Asplenium Nidus* dryness was not a factor and that the cause seemed to be either an unfavorable culture condition or an unknown physiological condition. The cases discussed in the present paper are too few in number to be of much significance. It cannot be a question of dryness, as the cultures were on

moist peat. They were, however, exposed to rather intense light. It seems to be true that one explanation will not answer for all cases; the factors which cause apogamy in *Woodsia ilvensis*, a



FIGS. 1–3, 5.—*Dicksonia squarrosa:* fig. 1, prothallium with two apogamous buds, ×22; fig. 2, section through *a*, ×210; fig. 3, section through *b*, ×210; fig. 5, section of prothallium with archegonia and archegonial projections, ×90. Fig. 4, *Cyathea Tussacii:* archegonial projection, ×170.

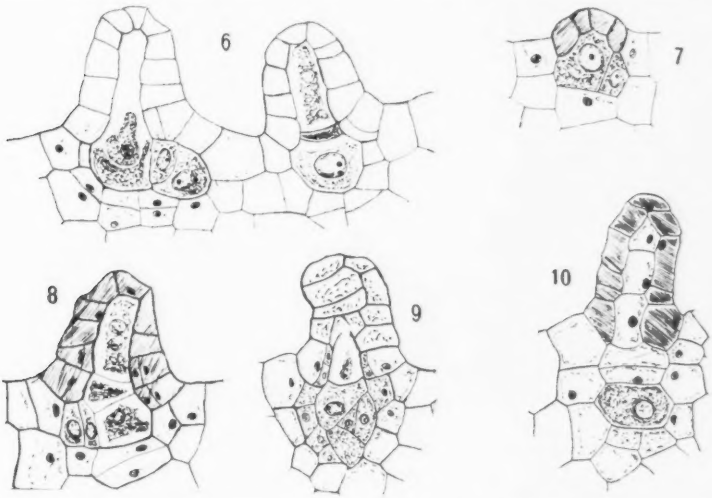
species which grows in exposed situations, are not necessarily the same as those which cause it in the species which grow in shaded places.

A convenient classification of types of apogamous development has been presented by FARMER and DIGBY (2), who begin their classification by distinguishing between premeiotic and postmeiotic apogamy. All the prothallia described in this paper were raised from spores, and accordingly the cases would be postmeiotic. The only case of obligate apogamy was found in a prothallium of *Dicksonia squarrosa* (Forst.) Sw. This prothallium had numerous antheridia and, although it was sufficiently large and had a well developed cushion, it had no archegonia. It produced two apogamous buds on the ventral side in the region where the archegonia usually appear (figs. 1, 2, 3). Behind one of the buds was a region where the thallus had thickened considerably and the outer cells had died. The presence of the characteristic cyatheoid antheridia makes it certain that this is not a polypod prothallium. Many prothallia of *D. squarrosa* showed the development of archegonial projections, such as HEIM (5) found on the prothallia of *Doodia caudata* and LANG found associated with apogamy in the species which he studied. Such projections are shown in figs. 4 and 5. *D. squarrosa* sometimes produced embryos as the result of fertilization, but these were not found on prothallia which had archegonial projections.

Cyathea muricata Wild. (*Alsophila muricata* Desv.) furnished the case shown in fig. 9. This may be the apogamous development of the oosphere, but it is quite as likely that it is the apogamous development of the ventral cell. Adjoining sections show that the archegonium had not opened. A nutritive region had begun to develop around the embryo. It will be noted that the shape and sequence of cell divisions are not the same as in the usual type of embryo.

In *Cyathea Tussacii* Desv. there were several cases of a peculiar behavior of the central cell. The first division does not cut off the primary neck cell, but instead cuts off a lateral cell (fig. 7). The central cell develops in the usual manner, while the lateral cell develops such structures as are seen in figs. 6 and 8. Such a division in the central cell was found also in *Dicksonia squarrosa* and a single case occurred in *Cibotium Schiedei* Schlecht. and Cham. *Cyathea Tussacii* and *Cibotium Schiedei* both produced archegonial

projections. In *Hemitelia horrida* (L.) R. Br. occurred the peculiar structure shown in fig. 10, an archegonium in which all the cells of the axial row except the egg have developed as vegetative tissue. The only development possible in this case would be an apogamous development. This species, however, showed no tendencies in that direction. It is impossible to say whether or not such structures as those shown in figs. 6, 7, 8, and 9 ever produce leafy



FIGS. 6–8.—*Cyathea Tussacii:* explanation in text, ×255; fig. 9, apogamous embryo of *Cyathea muricata*, ×255; fig. 10, peculiar archegonium of *Hemitelia horrida*, ×220.

sporophytes, as in a very short time it would be impossible to distinguish such an embryo from one produced as the result of fertilization. There was nothing in any of the material to indicate that these growths were ultimately checked, but the cultures did not continue long enough to show whether or not they would develop further. Neither species of *Cyathea* produced any embryos as a result of fertilization, although most of the archegonia appeared normal and the sperms were active, many being found in archegonia.

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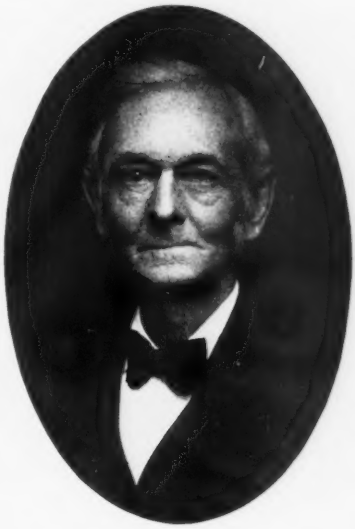
BRIEFER ARTICLES

CHARLES HORTON PECK

(WITH PORTRAITS)

Dr. CHARLES HORTON PECK, for many years Botanist of New York State, died at his home in Menands, New York, on July 11, 1917. He suffered a light stroke early in November 1912. A severe one in the spring of 1913 rendered him incapable of further work. Soon after this he presented his resignation as State Botanist, but it was not accepted by the Regents of the University of the State of New York until January 26, 1915. A testimonial minute was recorded at the time by the Regents, citing Dr. PECK's valuable services to the state and to science by his conscientious and untiring labors. Dr. PECK was greatly depressed early in 1912 by the death of his wife, and by the news that the herbarium would have to be moved from the Old Agricultural Hall to the new quarters in the State Education Building.



He was born at Sand Lake (now called Averill Park), New York, March 30, 1833. He graduated from the State Normal School at Albany in 1852. He then taught for three years in Schram's Collegiate Institute at Sand Lake. He entered Union College, Schenectady, in 1855, and graduated in 1859. He resumed his teaching at the Collegiate Institute in Sand Lake for three or four years. In 1862 or 1863 he was appointed teacher of Latin and Greek in the Albany Classical Institute, known more popularly as Cass's Institute, as it was presided over by AMOS CASS.

Here Dr. PECK is said to have become "an accomplished classical scholar, but his real interest lay all the time in the world of plants and flowers" (The Knickerbocker Press, Albany, July 12, 1917). It is evident, therefore, that for some time Dr. PECK had been engaged in the collection and study of plants. It may be a matter of interest to botanists to know the circumstance which first aroused his interest in botanical investigation which was so soon to supersede his interest in the classics. On two different occasions the writer had the opportunity of collecting and studying fungi for a week with Dr. PECK, first in the Adirondack

Mountains at Lake Piseco in 1902, and then at Port Jefferson, Long Island, in 1904. While at Lake Piseco Dr. PECK told the writer of the first impulse he received in the direction of the study of the lower plants. It was while teaching school at Sand Lake (probably in Schram's Collegiate Institute). One of his duties in those days appears to have been to help keep up the fire. While putting wood into the stove he was constantly attracted by the lichens and mosses growing on the bark. This gave him a desire to know something about the mosses. He got into communication with several students of the mosses at that time, probably LESQUEREUX[1] first, and later with C. F. AUSTIN.

[1] Rept. N.Y. State Cab. Nat. Hist. **19**:42. 1866.

Dr. PECK states[2] that ELLIOT C. HOWE, while at Fort Edwards, directed his attention to the study of the fungi and induced him to take up this field of investigation. He told the writer that he was advised to correspond with M. C. COOKE[3] of London concerning the fungi. This relation with COOKE is shown by the large number of new species of fungi published by PECK, in his early work, ascribed to COOKE and PECK. It appears that he received assistance in the determination of fungi from M. A. CURTIS before he became associated with COOKE. The first new species published by him was "*Septoria viridetingens* Curtis in litt.," in the 23d Rept. 55, 1873,[4] PECK being completely responsible for the diagnosis. He was, therefore, in correspondence with CURTIS at least as early as 1869, and probably earlier. During this period he was in correspondence also with other early students of the fungi, RAVE, PETERS, MICHENER, GERARD, FROST, and the Rev. J. BLAKE in this country. He had an extensive correspondence and exchange of specimens, not only with COOKE, but with other European mycologists, as DE THÜMEN, ROUMEGUÉRE, and others. Dr. PECK told the writer that he was advised to correspond with M. C. COOKE.

In the 18th Report (for 1864) of the Regents of the State of New York there is a catalogue of the mosses which were presented to the State Museum by Dr. PECK (pp. 193–196, 1864). In the 19th Report (for 1865, pp. 42–70, 1866) there is a list of the mosses of the state of New York by him. In the 20th Report (for 1866) there is an article by

[2] Bull Torr. Bot. Club **26**: 253. 1899.

[3] I have since forgotten the name of the person who made the recommendation, but it was one of three persons: E. C. HOWE, who had relations with the Rev. M. C. CURTIS of North Carolina, CURTIS himself, or the Rev. E. C. BOLLES, a Universalist clergyman of Salem, Massachusetts. Dr. FARLOW informs me that BOLLES, in the early seventies, was a well known popular lecturer on botany and zoology, and a great admirer of COOKE, who sent him many colored drawings and pamphlets on fungi. As BOLLES traveled about the country a great deal, he may have met CHARLES PECK; but the weight of evidence seems to indicate HOWE or CURTIS as the one who suggested COOKE to him. In this connection I wish to express my obligations to Dr. W. G. FARLOW, Mrs. E. G. BRITTON, Dr. H. D. HOUSE, the present State Botanist, and Mr. HARRY S. PECK, whom I recently met in Albany, for assistance in obtaining some of this information.

[4] This was the report for 1869, transmitted to the legislature March 10, 1870. In a letter to the writer, December 14, 1912, Dr. PECK stated that "the 23rd Report was published in 1873 as stated therein. A fire in the publishing house of Weed Parsons and Co. delayed the publication of the 23rd, so that the 24th got ahead of it." It is stated by some, however, that a separate of the botanical 23d Report was published in 1872.

him on "Facts and observations touching the flora of the state of New York" (pp. 403–410, 1867). This indicates that he was in touch with the scientific work of the Museum (then the State Cabinet of Natural History) before his appointment to the staff, and evidently enjoyed a close acquaintance with one of the Regents, himself a botanist, G. W. CLINTON, of Buffalo. He was appointed Botanist of the Museum in 1867. In 1883 the legislature created the position of State Botanist, to which Dr. PECK was appointed and which he held until his retirement in 1915.

He was most celebrated for his taxonomic studies and publications on the fungi, although seed plants, ferns, and mosses received considerable attention in nearly all of his reports, and quite a number of new species of seed plants were described by him. His activities in this field were not confined to New York State. He had many correspondents from all parts of the United States and Canada. His reports as State Botanist began with the 21st Museum Report for 1867 (published in 1868), and the last one by him was the Museum Report for 1912 (Bulletin 167, 1913). These reports have carried the name and work of Dr. PECK to all parts of the scientific world. With few exceptions the new species of fungi described in these reports included only those from New York State. Some of the early ones were published in the *Bulletin of the Buffalo Society of Natural History* and in the *Transactions of the Albany Institute of Arts and Sciences*. New species from territory outside of the state were mostly published in his numerous contributions to the BOTANICAL GAZETTE and to the *Bulletin of the Torrey Botanical Club*, dating from the very early history of these journals. His work covered all the groups of the fungi, and the new species described by him number between 2000 and 3000. A list of those published up to 1908 is given in the Museum Bulletin no. 131, pp. 59–190, 1909. These reports of the State Botanist have been in great demand by students of fungi, especially because there had been no manual of the fungi of North America.

The monographs of certain genera of the agarics form a very valuable feature of his work, particularly those appearing in a number of his later reports. His monograph of the Boleti of the United States (N.Y. State Mus. Bull. no. 8, 1889) should also be mentioned. He gave considerable attention to testing the edible properties of the fleshy fungi, as several of his reports testify. It is unfortunate that he was not able to complete monographs of all the genera of the agarics. During the

later years of his activity considerable time was given to study and collecting the Crataegi of the state for the State Herbarium.

Dr. PECK possessed a very critical and analytical mind. Many of his descriptions of new species are marvels of accuracy and clearness. On the two occasions when I had the opportunity of working with him in the field I was impressed by these qualities manifested in a marked degree. Each day he made a careful study of his collections, with full notes and often accompanied by colored drawings, from which were selected those for color reproduction in his reports. The photograph presented here, showing him at work, was made by the writer in his room at the hotel in Port Jefferson in 1904. On the table are some of the fungi, his water color blocks, and a color chart made by himself which he used for many years. Perhaps in some respects he was, at times, too critical, which may have led him to distinguish as different species environmental and growth forms of the same species, but in this respect he did not differ from most other taxonomists. This faculty, however, may be regarded as a virtue compared with the careless "lumping" so characteristic of some students who have taken a plunge into monographic work in the fungi without an adequate background of critical studies of the morphology and structure of the fleshy fungi in a fresh state. That a number of European species have been described by PECK (and others) as new is not surprising when we consider the poor and meager descriptions which appeared in the earlier, and some modern, European works on mycology.

This leads the writer to mention some of the other difficulties under which Dr. PECK labored. There has been a lamentable lack of proper equipment in apparatus, exsiccati, and of assistance in the Botanical Division of the State Museum, not to mention the very inadequate rooms and space which were assigned to the State Botanist. The latter feature has been vastly improved in the botanical quarters in the new Education Building, although even now there is no room suitably lighted for microscopic work. Dr. PECK, through nearly all the 48 years of his official connection with the Museum, worked single-handed and alone, carrying on his vast correspondence by hand, and caring as best he could for the large number of specimens collected by himself and communicated by his correspondents. Partly for this reason, and partly due to the fact that when the botanist's quarters were moved to the attic of the Capitol Building, most of the collections, for want of room, were bundled up and almost inaccessible; the collections

for a number of years were in a very chaotic state. When they were moved to the Agricultural Hall, some order began to come out of this chaos, and further improvement was introduced when an assistant (S. H. BURNHAM) was appointed. The present State Botanist, Dr. H. D. HOUSE, still has but one assistant. Nevertheless, the collections are being arranged in a more orderly manner; many of the types have been marked, and all are more accessible to students. For the care of this very valuable collection, and for the continuance and upbuilding of the botanical interests of the State Museum, New York should be more generous than it has been thus far.

Dr. PECK was a life member of the Botanical Society of America, a Fellow of the American Association for the Advancement of Science, member of the American Forestry Association, of the Albany Institute of Arts and Science, of the National Geographic Society, of the Torrey Botanical Club, and an honorary member of the New England Botanical Club.

The state and mycological science owe Dr. PECK a fund of gratitude for what he has accomplished in spite of the many difficulties and discouragements under which he labored. This recognition of his labors has been partly made by a testimonial to him, in the shape of a collection of colored models of some of the more important large fungi, which is displayed in the main museum room on the fifth floor of the Education Building.—GEO. F. ATKINSON, *Cornell University*.

A NEW POISONOUS MUSHROOM

(WITH THREE FIGURES)

The genus *Clitocybe* is a large one, with approximately 400 species. Very few of this large number are known to be poisonous or deleterious in other ways when eaten. Among these may be mentioned from North

FIG. 1.—*C. acromelalga* growing on ground in bamboo forest

America the phosphorescent species *C. illudens* Schw., which produces serious nausea, and *C. sudorifica* Pk., which, eaten in small quantities, causes a "profuse perspiration sometimes continuing for 5 or 6 hours" (N.Y. State Mus. Bull. no. 157. 68. 1912), but is "sufficiently toxic to cause the death of frogs, rabbits, and guinea pigs." It is a matter of

interest, therefore, to record the discovery of another poisonous species of this genus, which is also a hitherto undescribed one. It was found growing on the ground among other vegetation in a bamboo forest in Tsurugiji, Noto, Japan. The poisonous effects from eating this mushroom are manifested by an acute burning pain in the fingers and toes within 3 days. The pain is mitigated by placing the hands and feet in running water.

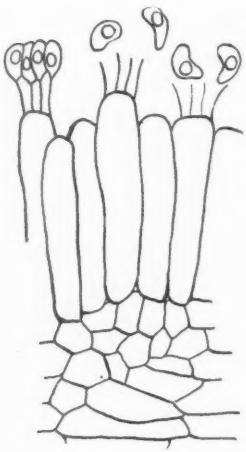


FIG. 2.—Basidiospores of *C. acromelalga;* ×1500.

Clitocybe acromelalga, n. sp.—Plants 3–6 cm. high; pileus 5–10 cm. broad, orange yellow when fresh, dark brown red when dry, subfleshy and pliant, depressed, margin incurved when young, splitting in age, surface smooth, flesh white; lamellae white, crowded, thin, slightly decurrent; basidia 4-spored; spores white, smooth, oboval, 3–4×1.5–2.5 μ; stem rigid, fibrous, hollow, concolorous with the pileus, 2–5 cm. long, 0.5–1 cm. thick.—Odor and taste not marked. Poisonous effects, *acromelalga.* October to November, on the ground in a bamboo forest, Tsurugiji, Noto, Japan.—T. ICHIMURA, *Kanazawa, Japan.*

FIG. 3.—*Clitocybe acromelalga*; ×$\frac{3}{4}$

CURRENT LITERATURE

NOTES FOR STUDENTS

Physiology of fungi.—The increasing attraction of this subject is evidenced by the number of papers that have appeared recently. The Graduate Laboratory of the Missouri Botanical Garden is publishing a series of such papers, 4 of which are noted herewith.

DUGGAR and DAVIS[1] deal with the often investigated problem of nitrogen fixation. Using a method by which the fungi were grown, digested, and distilled in the same flask without transfer, they were unable to demonstrate nitrogen fixation by *Aspergillus niger*, *Macrosporium commune*, *Penicillium digitatum*, *P. expansum*, and *Glomerella Gossypii*. In cultures of *Phoma Betae* on mangel and on sugar beet decoction with sugar, a nitrogen gain of 3.022–7.752 mg. was established, which they take to be a definite proof of fixation. A good review of the literature is included.

ZELLER[2] reports the following enzymes as occurring in a specially prepared enzyme powder from the wood destroying fungus *Lenzites saepiaria:* esterases, maltase, invertase, raffinase, emulsin, tarmase, diastase, inulanase, ligninase, cellulase, hemicellulase, pectinase, urease, hippuricase, nuclease, proteinase (both tryptic and ereptic), rennetase, oxidase, and catalase. Pectase and lactase were not demonstrated, and only slight indications were found of the presence of amidase. A comparative study of the enzymes occurring in sporophoral and mycelial tissue showed that the important metabolic processes are carried on in the latter.

ZELLER[3] also deals with the physical properties of wood in relation to decay. On the basis of an extensive series of tests, he concludes, contrary to the opinion of other workers in this field, that resin is no safe index of the durability of the 3 species of yellow pine investigated. If it increases durability at all, it does so more by its waterproofing effect than by the toxic effect on the growth of fungi sometimes claimed for it. As a more reliable and practical

[1] DUGGAR, B. M., and DAVIS, A. R., Studies in the physiology of the fungi. I. Nitrogen fixation. Ann. Mo. Bot. Gard. **3**:413–417. 1916.

[2] ZELLER, S. M., Studies in the physiology of the fungi. . II. *Lenzites saepiaria* Fries., with special reference to enzyme activity. Ann. Mo. Bot. Gard. **3**:439–512. 1916.

[3] ———, Studies in the physiology of the fungi. III. Physical properties of wood in relation to decay by *Lenzites saepiaria*. Ann. Mo. Bot. Gard. **4**:103–164. 1917.

criterion of durability, he recommends specific gravity, which, he says, is easily determined by inspection. The points to be noted are the proportion of summer wood to spring wood in the growth rings, and the width of the growth rings. If these are narrow, if the proportion of summer wood is high, and if the proportion of sap wood is low, the piece of pine can be considered of high specific gravity and therefore durable.

DUGGAR, SEVERY, and SCHMITZ[4] have made a study of the growth of *Macrosporium commune*, *Aspergillus niger*, *Glomerella* (*Glocosporium*) *Gossypii*, and *Penicillium expansum* on decoctions made from green string beans, corn meal, fresh turnips, sugar beets, dried prunes (exclusive of seed), and potatoes. Besides the natural decoctions, variants of these were used, containing, in addition to the plant extracts, different amounts of acid or alkali, cane sugar, potassium nitrate, and potassium acid phosphate. They found that the addition of sugar, nitrate, and phosphate gave in every case except one (*Glomerella* on bean decoction) increase in growth over the addition of sugar alone. Usually the next highest growth occurred when sugar and nitrate were added. Sugar alone gave a relatively slight increase over the natural decoction. The prune decoction seemed less favorable for growth than any of the others, except in the case of *Macrosporium*. Hydrogen-ion determinations, made by the colorimetric method, showed that in all solutions except the sugar beet and the corn meal decoctions *Aspergillus* caused a shift toward the acid side usually about 10^{-3}, while *Macrosporium* and *Glomerella* generally caused a pronounced shift in the other direction. It is worthy of note here that REED[5] found an increase in alkalinity in cultures of *Glomerella rufomaculans*, while the writer[6] has shown the same condition to hold in case of apple bark attacked by blister canker (*Nummularia discreta*). *Penicillium* caused an increase in acidity in the natural and standardized decoctions.

From the results of an investigation of the mosaic diseases of plants, FREIBERG[7] comes to the conclusion that the infectious substance is an enzyme and not a virus, as ALLARD claims to have shown in recent work on the mosaic disease of tobacco. FREIBERG's reasons for his conclusion are that the infective principle is adsorbed by talc, and is destroyed by concentrations of alcohol and by temperatures which are destructive to enzymes. The fact that the infective principle is destroyed by formaldehyde is due, he thinks, to a specificity

[4] DUGGAR, B. M., SEVERY, J. W., and SCHMITZ, H., Studies in the physiology of the fungi. IV. The growth of certain fungi in plant decoctions. Ann. Mo. Bot. Gard. **4**:165–173. 1917.

[5] REED, H. S., The enzyme activities involved in certain fruit diseases. Va. Exp. Sta. Rept. 1911–1912 (pp. 51–78).

[6] ROSE, D. H., Oxidation in healthy and diseased apple bark. BOT. GAZ. **60**:55–65. 1915, and unpublished work.

[7] FREIBERG, G. W., Studies in the mosaic diseases of plants. Ann. Mo. Bot. Gard. **4**:175–232. 1917.

of reaction between the two and not to the antiseptic properties of the formaldehyde. This explanation he finds further supported by the fact that the infective power of extracts from diseased plants is not destroyed by treatment for two days with concentrated solutions of ether, chloroform, carbon tetrachloride, toluene, acetone, and glycerine. In this connection it is well to remember a statement by SMITH[8] that in a number of organisms tested by him 10 grew in the presence of chloroform (5 cc. of chloroform in test tubes with 10 cc. of milk or beef bouillon), and 2 grew vigorously in the presence of thymol. He further states that, "in the opinion of the writer, statements of physiologists respecting the existence of enzymes in the tissues and fluids of higher plants must be taken with much allowance when chloroform, thymol, and similar antiseptics have been depended upon to keep the solution free from bacteria. A medium to which chloroform or thymol has been added must be shut in and shaken continuously if the full antiseptic value of these substances is to be obtained."

Microchemical tests showed starch and sugar present in greater amounts in the dark green than in the chlorotic areas. FREIBERG suggests that this condition, taken in connection with the specificity of reaction between formaldehyde and the infective principle, and the possibility that formaldehyde is one of the first products of photosynthesis, may form a basis upon which the physiological nature of mosaic diseases may be explained. The possible relation of these factors to the formation of an enzyme is not made clear. Neither is it made clear how an enzyme can "reproduce itself." If it does so, why is not ALLARD'S contention the better one, that the causal agent is an organism and not an enzyme? And if it be granted for the sake of argument that the blotching of the leaves is caused by an enzyme, the question of the origin of the enzyme is still unanswered. In the work of ABERHALDEN and of KNUDSON, cited by FREIBERG, the development of proteolytic enzymes or of tannase was not spontaneous, but resulted from a stimulus foreign to the organism.

Yellows or wilt, a serious disease of cabbage in many parts of the country, has recently been investigated by Gillman.[9] He finds that the causal fungus, *Fusarium conglutinans* Wollenw., has a high optimum temperature and is very resistant to drying, both in pure culture and in the soil. The characteristic symptoms of the diseases are dependent on a temperature of about 17–22° C. or above for their occurrence. Lower temperatures (12–16° C.) under controlled conditions prevented the occurrence of the trouble in the greenhouse.

Two rusts of economic importance, *Puccinia coronata* Cda. and *P. Sorghi* Schw., are the subject of a physiological investigation by MAINS.[10] The

[8] SMITH, E. F., Bacteria in relation to plant diseases. Ann. Mo. Bot. Gard. 1:74, 75. 1905.

[9] GILLMAN, JOSEPH C., Cabbage yellows and the relation of temperature to its occurrence. Ann. Mo. Bot. Gard. 3:25–84. 1916.

[10] MAINS, E. B., The relation of some rusts to the physiology of their hosts. Amer. Jour. Botany 4:179–221. 1917.

optimum temperature for the former is put at about 20° C., for the latter 30°. The fact that no injury appears in the infected cells, but only in the cells surrounding them, is thought by MAINS to be due to starvation brought about by withdrawal of foods to the infected region. It is possible, however, that the injury might be caused by injurious enzymes or other toxic substances which diffuse outward from the infected cells. The growth of the rusts and the development of spore pustules were increased when some carbohydrate was added to the nutrient solution, and the conclusion is drawn that "the obligate parasitism of the rusts is probably explained by their requirement of some transitory or nascent organic products related to the carbohydrates which they obtain in the living plant." This conclusion is hardly in accord with the statement made by RUSSELL[11] that wheat plants whose photosynthetic activity has been seriously decreased by lack of potash, and whose carbohydrate content is therefore low, are especially susceptible to attacks of rust. Further work seems necessary to clear up the situation.

BROOKS and COOLEY[12] find that in inoculations on apples all of the fungi tested grew at 0° C. except *Fusarium radicicola* and *Glomerella cingulata*, the former making no growth at 15° and the latter none at 10°. *Sphaeropsis malorum* had produced no evident rot at 15° by the end of a week, the species of *Penicillium* and *Neofabraea* at 10° by the end of two weeks, while *Sclerotinia cinerea* produced measurable rots at 5° in one week and at 0° in two weeks. *Neofabraea malicorticis* had an optimum at 20°, *Fusarium radicicola* at 30°, and all the other fungi at 25°. When grown on corn meal agar in Petri dishes, all the fungi showed the same optimum and maximum as in the fruit inoculation experiments. With most of the fungi the initial incubational stages of growth on the fruit were more inhibited by low temperatures than the later ones. The results of the investigation show the importance of immediate as compared with delayed storage; the value of temperatures of 5 or 10° in short periods of storage, and of 0° in longer ones; and further that the minimum temperature varies with the prevalent fungus and with the variety and maturity of the fruit.

In an investigation of the growth of fungi on nutrient solutions by HAWKINS[13] it was found that *Aspergillus niger*, *Penicillium glaucum*, and *Botrytis cinerea* grew readily in solutions of potassium and calcium nitrate, sucrose, and glucose in which the diffusion tensions were much higher than the total diffusion tensions of the dissolved substances in the juices of their host plants.—D. H. ROSE.

[11] RUSSELL, E. J., Soil conditions and plant growth. 2d ed. London. 1915 (pp. 41, 42).

[12] BROOKS, CHARLES, and COOLEY, J. S., The temperature relations of apple-rot fungi. Jour. Agric. Research **8**:139–163. 1917.

[13] HAWKINS, LON A., Growth of parasitic fungi in concentrated solutions. Jour. Agric. Research **7**:255–260. 1916.

Endemism.—RIDLEY[14] recently presented a series of criticisms of the work of WILLIS on endemism in Ceylon. WILLIS had attempted to demonstrate by the statistical method that endemics were the most recent rather than the most ancient forms in a given locality. In his criticism RIDLEY objected that the statistics used were inaccurate, pointing out a number of flaws. In addition he presented from his own experience some striking exceptions to the general conclusion of WILLIS. In conclusion, RIDLEY objected to the use WILLIS had made of the mutation theory, RIDLEY himself evidently being a confirmed natural selectionist.

WILLIS[15] has now answered these criticisms in a rather satisfactory way. As to the flaws in his statistics, he points out how they are quantitatively of little significance. As to the applicability of his conclusions, he presents two crucial cases: (1) showing that the widely distributed forms of New Zealand "take no notice" in their distribution of Cook's Strait (of relatively recent origin), while the endemics do; (2) the "local distribution of the highly modified Tristichaceae and Podostemaceae and the cosmopolitan distribution of the little modified forms." As to man's action, changes of climate, and similar disturbing factors which RIDLEY had accused him of neglecting, WILLIS stated that these, although they may exert a disturbing influence, no more affect the validity of his law than does the resistance of air effect the law of gravity. Finally, WILLIS deals with RIDLEY's theoretical objections merely by pointing out that natural selection cannot explain the origin of the peculiarities which distinguish plants, but can only preserve or destroy them when once formed.

In an accompanying paper SINNOTT[16] raises additional objections to the hypothesis of WILLIS. He says that "other factors than age determine the area occupied by a species." He can hardly claim, however, that this affects the validity of the law. He also states that the data of WILLIS would seem to indicate that woody plants are producing new species faster than are herbs, a conclusion against which there is much evidence; and likewise they would indicate that herbs are the older since they are the more widely distributed. BAILEY and SINNOTT had previously stated and substantiated the contrary view. May not the two ideas be reconciled, however, by the fact that it is the nature of herbs to spread the more rapidly, due to more meager requirements for germination and to more extensive vegetative multiplication? SINNOTT also states that species *are* dying out, due to actual extermination, "which causes the last survivors to appear as 'relic' endemics"; and by "swamping" of isolated members of old species by crossing with newly devel-

[14] Rev. in BOT. GAZ. **64**: 263. 1917.

[15] WILLIS, J. C., The relative age of endemic species and other controversial points. Ann. Botany **31**: 189–208. 1917.

[16] SINNOTT, EDMUND W., The "age and area" hypothesis and the problem of endemism. Ann. Botany **31**: 209–216. 1917.

oped forms. WILLIS had concluded that species are *not* dying out. In conclusion, SINNOTT emphasizes the complexity of the problem and points out the many factors involved. The complexity of a problem, however, should justify rather than discourage the development of such a theory.—MERLE C. COULTER.

Free ammonia and ammonium salts in plants.—WEEVERS[17] has made a large number of determinations for free ammonia and ammonium salts in tissues of various members of the plant kingdom. Tests for ammonium salts were made as follows: a portion of the plant material (25 mg.) along with a drop of water was placed in the bottom of a collared microscope slide. Some powdered magnesia and a wad of cotton bearing a little chloroform were added. A cover glass bearing a hanging drop of platinic chloride was then placed on the collar. The chloroform killed and rendered the cells permeable, while the magnesium oxide liberated the ammonia from the ammonium salt of the tissues. The ammonia was detected by the $(NH_4)_2Pt\ Cl_6$ crystals in the hanging drop. For the detection of free ammonia only the tissue or the tissue and the chloroform were added along with the hanging drop. Sodium hydrate (20 per cent) could be substituted for magnesia only in case the reaction was rapid, for the former liberates ammonia from amides in a few hours at room temperature. WEEVERS believes he could estimate closely the relative amount of ammonium salts in various tissues by the amount of $(NH_4)_2Pt\ Cl_6$ crystals formed. His estimates tallied with the quantitative determinations that were made in many cases.

Among phanerogams free ammonia was found only in bacterial nodules. In cryptogams it was occasionally found in Hymenomycetes and lichens. Ammonium salts were found in all species examined except in some mycotropic and insectivorous forms naturally growing on acid moorlands poor in ammonium salts. Their absence in these forms is apparently related to the nature of their protein metabolism and not to nitrogen shortage in the soil, as indicated by their behavior in water cultures and by other plants of the same habitat bearing ammonium salts. The amount of ammonium salts present in the leaves of any plant is apparently independent of their presence in the soil. Ammonium salts that are absorbed by the roots from water cultures are quickly transformed and do not influence the amount in the leaves. Many facts indicate that these salts result from protein metabolism, assimilation, and dissimilation. The more vigorous metabolism in any part the more ammonium salts are present. Some plants and plant parts are rather rich in ammonium salts, bearing as much as 2 per cent; certain sea forms (*Noctiluca miliaris*); many hymenomycetes and lichens (excepting lichens on moorlands); certain Liliaceae and Cruciferae (onion and cabbage roots), and root nodules of

[17] WEEVERS, TH., Das Vorkommen des Ammoniaks und der Ammonsalze an den Pflanzen. Rec. Trav. Bot. Neerland. **13**:63–104. 1916.

Papilionaceae. The author believes that certain of the mycotropic forms are limited to acid soils because of the use, through the help of their mycorrhiza, of organic nitrogen compounds, and these are most abundant in absence of lime. —WM. CROCKER.

Hybrids of maize.—COLLINS[18] makes a contribution to the genetics of maize by reporting results from his studies of hybrids between pod corn and a type discovered by Dr. W. B. GERNERT, in which the pistillate inflorescence is replaced by a compound inflorescence branched as is ordinarily the case with the tassel.

In his experiments the progeny of ordinary *tunicata* plants has always consisted of approximately 3 tunicates to 1 normal. In other words, the usual tunicate ear is a heterozygous dominant. The homozygous dominant is apparently a type which makes up about one-third of the total number of tunicate plants and is characterized by greatly enlarged tassels containing both staminate and pistillate flowers, and the ear either with enlarged sterile spikelets or wanting. *Zea ramosa*, on the other hand, is recessive to normal.

In 1914 a cross was made between half-tunicate (heterozygous) ♂ and *Zea ramosa* ♀. Of 9 first generation plants, 4 were tunicate and 5 normal, the tunicate ears being "half-tunicate" and showing no trace of *ramosa* characters. From 2 selfed F_1 non-tunicate ears 85 plants were raised, of which 65 were normal and 17 *ramosa*. From 3 selfed F_1 half-tunicate ears 326 plants matured. Among the *tunicata* plants of this lot there were both *tunicata* and *ramosa* tassels, and in the latter a new type appeared which had indeterminately branched inflorescences embryonic in nature. This peculiar type (termed cauliflower) occurred in both lateral and terminal inflorescences, although more common in the former. A simple Mendelian interpretation of these results is given.—E. M. EAST.

A New Zealand biological station.—Canterbury College has recently set apart a tract of land in the mountainous center of South Island, New Zealand, and provided it with buildings suitable for a biological station. It is situated at an altitude of 1850 ft. on the Cass River and is surrounded by mountains, some of which are over 5000 ft. high. Descriptions of its situation,[19] its physiography,[20] and its vegetation[21] seem to show that it is well suited to the purpose for which it was intended. The vegetation displays a wide

[18] COLLINS, G. N., Hybrids of *Zea ramosa* and *Z. tunicata*. Jour. Agric. Research **9**:383–395. *pls. 13–21*.

[19] CHILTON, CHAS., Introduction and general description of station. Trans. New Zealand Inst. **47**:331–335. 1915.

[20] SPEIGHT, R., The physiography of the Cass district. *Ibid.* **48**:145–153. 1916.

[21] COCKAYNE, L., The principal plant associations in the immediate vicinity of the station. *Ibid.* **48**:166–186. 1916.

diversity of types, including bits of forests of the southern beech, *Nothofagus Cliffortioides*, various scrub associations, and low tussock grassland, with transitions through reed and sedge swamp to open water. Of these the tussock grassland is by far the most important and interesting, representing as it does a montane association covering some 6,000,000 acres ranging from an altitude of 1000 to 3000 ft. It is dominated by the two smaller tussock grasses, *Poa caespitosa* and *Festuca nova-zealandiae*, in many places changed by burning and sheep grazing so as to permit the invasion of other grasses and herbs. The association not only presents many interesting ecological problems, but its proper utilization is a matter of great economic importance,[22] since one-seventh of the occupied land of New Zealand is covered with this vegetation. At present it is largely given over to sheep grazing, but without producing satisfactory returns.—GEO. D. FULLER.

Anatomy of Gnetum moluccense.—LA RIVIÈRE[23] has described the structure of a single branch of *Gnetum moluccense*. The greater part of the paper is devoted to a study of the accessory (secondary) steles outside of and concentric with the first stele. The remarkable conclusion is reached that they originate in the nodes from ramifications of bundles passing to the lateral branches and then grow *downward* (toward the base of the stem), the cambiums appearing at lower and lower levels in the inner cortex. The difficulties in this conception, that the direction of their growth is the reverse of the usual one, will present themselves to both morphologists and physiologists. Communications of the accessory steles with each other and with the central one, originally discovered by BERTRAND but overlooked by all later workers, are carefully traced and appear to be quite numerous. The different tissues of the whole stem are briefly described, but according to the author's observations present no features of outstanding morphological significance. This is perhaps the reason that no conclusions are mentioned in regard to the affinities of Gnetales with either gymnosperms or angiosperms.—W. P. THOMPSON.

Nitrogen determination.—Several years ago FOLIN modified the Kjeldah method of determining nitrogen so that small quantities could be determined with sufficient accuracy. DAVIS,[24] who has used this modified method extensively for determination of nitrogen in small quantities of plant materials, reports that it is specially good for demonstrating proteolytic changes, for determination of nitrogen in minute plant sections or organs, and the effects of various factors upon the nitrogen content of plant tissues. The method is

[22] COCKAYNE, A. H., Some economic considerations concerning montane tussock grassland. *Ibid.* **48**:154–165. 1916.

[23] LA RIVIÈRE, HENRIETTE C. C., Sur l'anatomie et l'epaississement des tiges du *Gnetum moluccense* Karst. Ann. Jard. Bot. Buitenzorg **30**:32–58. *pls. 4–12.* 1916.

[24] DAVIS, A. R., A note on the adaptability of the Folin micro-Kjeldahl apparatus for plant work. Ann. Mo. Bot. Gard. **2**:407–412. 1916.

best suited to amounts of nitrogen running from 0.5 to 5 mg., and the substance taken for determination should correspond to such quantities of nitrogen. The apparatus consists of small Kjeldahl flasks, fume absorbers, micro-burners, Ostwald pipettes, and small condensers, all readily obtainable or easily constructed. Titration is used, rather than the colorimeter method, for the actual determination. A comparison of the determinations with the micro- and macro-Kjeldahl method shows that the micro method can be relied upon as reasonably accurate. The method will be exceedingly valuable with advanced classes in physiology.—CHARLES A. SHULL.

Carbon nutrition.—The ability of *Glomerella cingulata* to utilize certain pentosans and pentoses as a source of carbon has been investigated by HAWKINS.[25] He finds that arabin and xylan, and the derived sugars, arabinose and xylose, may be used as the sole source of carbon. When this fungus causes rot in apples, it decreases the total furfurol-yielding content of the apple, but the alcohol-soluble portion of the furfurol-yielding material is increased. This change indicates that the pentose sugars are split off from the more complex pentosans of the apple. The enzyme producing this change was sought. Filtered extract of the mycelium, acting under aseptic conditions, is able to change xylan to xylose, but it loses its power when boiled. It is clear, therefore, that a xylanase is present in the fungus or its extract which can hydrolyze xylan.—CHARLES A. SHULL.

Plant formations of Canada.—In a brief bulletin of less than a score of pages MACOUN and MALTE[26] have outlined some of the most strikingly characteristic plant formations of Canada and noted their distribution and dominant species. It will serve to give some idea of the flora as a whole, and will indicate the wide diversity to be found, extending as it does from rich mesophytic forests of conifers and deciduous trees to xerophytic grassland and Arctic tundras.—GEO. D. FULLER.

Californian plants.—An addition to our knowledge of the vegetation of a portion of the Sierra Nevada Mountains comes in the form of an annotated list of species by PARISH[27]. The region includes associations of chaparral and conifer forests; among the latter *Pinus monophylla*, *P. ponderosa*, and *P. Murrayana* dominate at different altitudes.—GEO. D. FULLER.

[25] HAWKINS, L. A., The utilization of certain pentoses and compounds of pentoses by *Glomerella cingulata*. Amer. Jour. Bot. **2**:375–388. 1915.

[26] MACOUN, J. M., and MALTE, M. O., The flora of Canada. Can. Geol. Survey. Museum Bull. **26**:14. 1917.

[27] PARISH, S. B., An enumeration of the Pteridophytes and Spermatophytes of the San Bernardino Mountains, California. Plant World **20**:163–178, 208–223, 245–259. 1917.